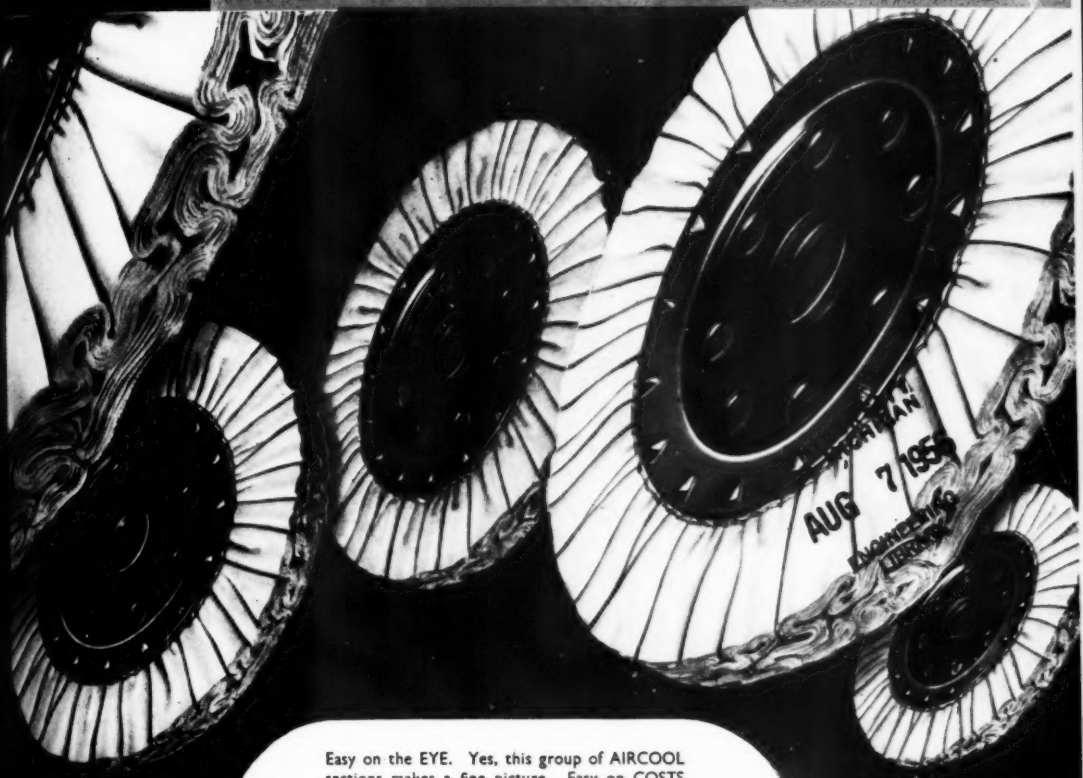
finishing

ANT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, ALVANIZING, METAL SPRAYING and all METAL FINISHING PROCESSES

Vol. 2 No. 18 (new series) JUNE, 1956



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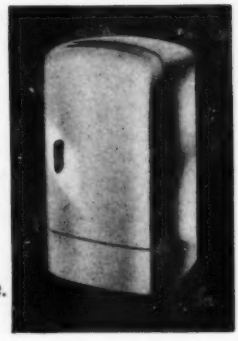

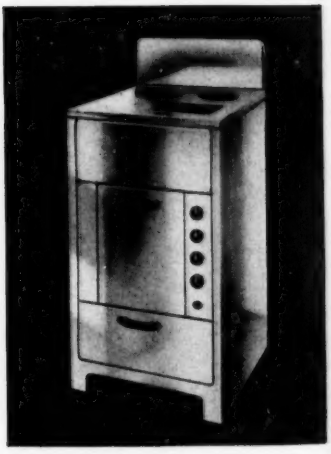

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JUNE, 1956 AN INDUSTRIAL NEWSPAPERS PUBLICATION Vol. 2 No. 18 (New Series)

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Telephone: Ripley 136

Published on the 15th of each month by

INDUSTRIAL NEWSPAPERS LIMITED

Chairman and Managing Director:
Barrington Hooper, C.B.E.
Commercial Director:
F. Barrington Hooper, B.A.
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JOHN ADAM HOUSE
17-19 JOHN ADAM STREET
ADELPHI, LONDON, W.C.2

Telephone: TRAfalgar 6171 (P.B.X.)
Telegrams: Zacatecas, Rand, London

Subscription Terms:
Home and Overseas 24*s.* per annum prepayable
Single copies 2*s.* (2*s.* 4*d. post free*)

THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING AND ALL METAL FINISHING PROCESSES.

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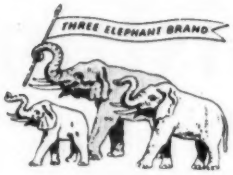

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WASTED OPPORTUNITY

AN electroplating plant can represent a lot of capital, while labour and materials at the present time are both scarce and costly. It would therefore appear to be a basic tenet in the operation of a plating shop that the maximum effective use should be made of plant, labour and materials. The whole concept of efficient utilization of these basic resources has been brought within the ambit of the generic term 'productivity,' and the level of productivity in the electroplating industry has recently been subjected to critical scrutiny.

This has been made possible by the provision of a grant from the International Co-operation Administration to the British Non-Ferrous Metals Research Association, who appointed two of their staff, well versed in plating matters, as a team to investigate current plating practice in this country and to report thereon.

The report of this team has now been published by the Association, and has been discussed at conferences in London and Birmingham attended by satisfactory numbers of representatives of the industry. The report itself shows clear evidence of careful preparation and considered opinion and does not hesitate to list or illustrate the numerous examples of inefficiency or inadequacy observed in the course of surveying twenty-nine electroplating concerns. For obvious reasons the firms concerned are nowhere identified in the report but it can be assumed that their practice can be taken as typical of that obtaining in the majority of plants operating in this country.*

In the main the report does not level any serious charges of inefficiency at the industry, although it makes it clear that there are many ways in which minor improvements can be brought about whose sum might make a highly significant total of benefit. However, the industry notably failed to make effective use of the opportunity provided by the sponsors of the report to discuss the findings with the team and with other informed authorities. As mentioned above both conferences were well attended by those who might have been expected to have been most interested in the subject matter of the report and from whom questions should have been forthcoming concerning the recommendations and their implementation.

It is regrettable therefore that the whole tenor of the meeting bore no relation to the subject matter of the report or indeed to the question of productivity at all. It is true that numerous questions were asked and capably answered. Indeed, discussion was at all times brisk albeit unhappily, largely irrelevant. Responsibility for this can in no wise be attributed to the respective chairmen of the meetings, who frequently strove unsuccessfully to restore the discussion to more proper channels. It can only be assumed that the industry continues to be blinded by the dazzle of full order books to the need of using the present time of prosperity to put its house into proper order so that should leaner times prevail they can be faced in confident knowledge that every £1 of capital, every ounce of material, and every man-second of labour is earning its keep.

Such an eventuality will not arise by chance or blissful hope. It can only be brought about by constant vigilance and the proper application of work study and scientific costing methods.

Genuine self criticism is one of the hardest virtues to acquire and one of the most financially rewarding as far as industry is concerned. If the evidence of the reaction of the industry towards the B.N.F.M.R.A. report is of any significance it is a faculty still lacking in the electroplating industry.

* "Productivity in Electroplating—A Survey of a Cross-section of the Electroplating Industry". Development Report No. 56. Published by the British Non-Ferrous Metals Research Association, 89-91, Euston Street, London, N.W.1.

Talking Points by "PLATELAYER"

TOPICAL COMMENT FROM THE MAIN LINES AND SIDE LINES OF METAL FINISHING

NO VACANCIES FOR GENIUSES?

THE emphasis on the team spirit in research, and the feeling which is widespread in industry that the individual can do very little in face of the complexity of the problems that have to be dealt with today, has one real disadvantage. It means, in effect, that there is no room in large scale industry for the brilliant, or the unorthodox individual, who does not fit in with the group and who therefore, sometimes in desperation, decides to branch out on his own. He may make a success of his enterprise, but often with limited resources, he fails to do so and the nation is the poorer for it.

It is to the out-of-the-rut, forward-looking men who are in such a minority today to whom we should pay more attention. For there are two major ways of tackling a problem. The first is to have a large team slogging the hard way through a mass of experimental and test work, and arriving ultimately, after much time and labour, at a solution. The second method, is to have a much smaller number of people of exceptional calibre who can see the way to the answer through the excerise of what for want of a better word, may be called genius. It is in the second method that this country has always excelled, and on which we should do well to concentrate, in view of our limited resources in manpower and materials. Even with the expansion of our technical colleges and educational facilities, the number of scientists we can produce will be limited. Would it not therefore be advisable to pay more attention to those of exceptional quality, and should not industry be prepared, to some extent at any rate, to adapt its organization and its systems to give them scope for their enterprise and ideas? It looks as though there is a need for someone to start doing research on research.

THE OLD STORY

ONE of the most interesting aspects of the findings published in the Third Interim Report of Joint Technical Panel J/P1 of the British Iron and Steel Research Association, which has been studying the performance of a wide range of priming paints for the past seven years, is the complete justification of the adage that the old remedies are best. The results of the examination of the numerous test panels exposed at Brixham and at Derby are too complex to describe here, but the main conclusions seem to be these: (1) that all the best paints were based on a linseed stand oil/alkali-refined linseed oil medium, and (2) that the protective value of a paint film increases approximately in proportion to its thickness. So, after all the developments of modern times in synthetic resins and coating materials, we come back to the fact that the paint medium used by the Ancient Egyptians is still the best, and that the more coats you can apply the better. This matches a recent report on the excavations in Italy where it has been found that the bronzes discovered at some ancient smelting sites there, for some reason give sharper and better defined castings than the bronzes known to present-day metallurgists.

Although many of our advances in materials and processes result in better products, there are quite a number of cases where the achievements are mainly in the direction of producing them quicker, cheaper—and a little inferior.

SUPER-COLOSSAL

SOME time ago we reported that a new electro-deposited coating consisting of a tin-nickel alloy had been "discovered" in Holland. It is gratifying therefore to report that this country also does not lag behind in finding new finishing processes. A note in a motoring weekly recently announced that "a new process for the rust protection of mass produced steel components has been introduced." Breathlessly we proceeded to read that "this new application of phosphating will result in the virtual elimination of corrosion on mild steel goods of all types so far as it is humanly possible to achieve such protection." From this we can deduce that all further research in this field is useless if carried out by human beings and that no further progress can ever be achieved by our species. The next advance can only be made, presumably, by calling in the Martians.

The process is actually a spray-applied accelerated manganese phosphate, and while it may possess some novel features, I cannot believe that the interests of its sponsors or of the metal-finishing industry in general are well served by the indiscriminate use, in Technical writing, of superlatives of the Hollywood type.

Chemical and Electrolytic POLISHING of Non-Ferrous Metals†

by P. GRIVEL*

Chemical Polishing

IN addition to the already familiar mechanical polishing methods, as used for producing metallographic specimens or for finishing some kinds of surfaces, electrolytic, and later chemical polishing techniques have been developed during recent years. In the interests of a proper documentation of the subject, the present author, about a year ago, made an investigation into the problems of chemical polishing, in the laboratories of the *Metallwerke A.G.*, Dornach.

The purpose of the investigation was to draw attention to this relatively new technique, which should interest very many industries faced with this problem.

In general, the chemical polishing process consists of a simple dipping process in which the article to be polished is placed in a bath of a particular composition, and the method has the great advantage, compared with electrolytic polishing, of not requiring rectifiers, bath voltage regulators or any measuring instruments. It only requires suitable tanks, according to the size of the article(s) to be treated, which may be of enamel, glass, earthenware, stainless steel, porcelain, plastic, etc.

The mechanism of chemical polishing depends essentially on the formation during the operation, on the surface to be polished, of a film with specific properties. This film is thicker in the surface depressions than on the protuberances; hence, the polishing effect is greatest on the latter. This is the condition producing a smooth (polished) surface. The film requires to be of a controlled degree of viscosity, and for this control the presence of phosphoric acid plays an important part.

Before considering the chemical composition of the different polishing baths in use, it must be mentioned that the degree of polish obtained by this method is limited. While suitable mechanical methods make it possible to obtain all degrees of polish up to a mirror finish, chemical polishing cannot always give such good results. The articles do become bright, but their reflecting power is less. This may be due to:—

1. Flaws on the surface of the material, *e.g.* minute inclusions, scratches, tool marks (chatter marks), etc.;
2. Depending on the conditions of chemical attack, immersion time, bath composition, alloy composition, different degrees of polish are obtained. The surface may appear slightly granular, the pattern then being wavy, with the crystalline structure apparent, instead of smooth and flat.

The particular advantage of chemical, as well as electrolytic, polishing is the possibility of treating objects of intricate form, which cannot be mechanically polished.

The solutions used in chemical polishing are acids or acid mixtures, selected according to the metal or alloy to be treated, but for aluminium, alkaline solutions are also used. A great number of solution compositions exist, but the number of those most suitable is limited.

A survey of this problem was published in the U.S.A. in 1948. (U.S. Patent 2,446,060 of 27 July, 1948) which covered 16 different solutions, based on a ternary diagram, and giving quantitative percentages for nitric, acetic and phosphoric acids.

The contents in volume percentages varied within the following limits:—

Acetic Acid, CH_3COOH, conc. (S.G. 1.05) 10 to 80 per cent.

Nitric Acid, HNO_3, conc. (S.G. 1.42) 20 to 50 per cent.

Phosphoric Acid, H_3PO_4, conc. (S.G. 1.7) 10 to 80 per cent.

Water max. 10 per cent.

The survey also recommended the addition of such substances as chromic acid, sulphamic acid, etc., those having the property of reducing the amount of gassing. Traces of chlorides, (*e.g.* NaCl) or hydrochloric acid (HCl) improve the polishing effect in amounts of 0.05 to 1.5 per cent. The immersion time of the material varies according to the particular alloy between 5 sec.

* Ing. Chim. Dipl. E.P.U.L. c/o Fonderie Boillat, S.A., Reconvilier.

† Reproduced in English from *Pro-Metal*, 7, 47, Oct., 1955 by courtesy of the Editor.

TABLE 4.
Solutions Employed

No. of Bath and Origin	Acetic Acid (CH_3COOH) (S.G. 1.05)	Phosphoric Acid (H_3PO_4) (S.G. 1.7)	Nitric Acid (HNO_3) (S.G. 1.42)	Various additives
1* Germany	25%**	55%	20%	0.5% HCl
2 Germany	15%	65%	2%	18% water
3 U.S.A.	5%	30%	65%	possibly 1.0% NaCl + 5% H_2O
4* U.S.A.	25%	55%	20%	0.5% HCl
5 U.S.A.	40%	40%	20%	0.01% HCl
6 U.S.A.	30%	30%	40%	possibly 1.0% NaCl + 15% H_2O
7 U.S.A.	40%	10%	50%	

*Baths 1 and 4 are identical in composition and formed a single bath in the tests.
**The percentages are by volume. The acids used are all concentrated, corresponding to the densities given in the table. The immersion time of the samples was 5, 15, 30 seconds, 1 minute, 5, 15 minutes.
All tests were made at room temperature without agitating the bath.

and 15 min. and the temperature similarly varies within fairly wide limits (18 to 150°C.).

Further investigations were carried out in Germany using baths of identical, or very similar composition. All the baths can be used for polishing non-ferrous metals, excepting aluminium.

Other German investigators recommend a bath of the following composition:—

25 per cent conc. acetic acid, 20 per cent conc. nitric acid, 55 per cent conc. phosphoric acid, 0.5 per cent conc. hydrochloric acid, 0.1 per cent alkyl-ammonium sulphate. The added water varies between 5 and 10 per cent.

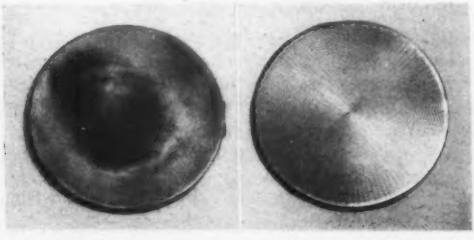
Other investigators consider the presence of nitrous acid (HNO_2) as being necessary, implying a nitric-acid content of not less than 5 per cent. In fact, the nitrous acid forms of its own accord during the polishing process, but the rate of formation depends on the water content of the solution; for the best results, this should be between 15 and 22 per cent.

For aluminium, a similar bath of the following composition has been suggested:—

15 per cent acetic acid, 65 per cent phosphoric acid, 2 per cent nitric acid and 18 per cent water.

This variety of proposed bath compositions and the possibility of combinations would appear to indicate that good results are fairly easily attainable. In practice, however, the problem presents difficulties because of the multiplicity of solutions suggested and it is not easy to find the ideal solution, and its particular conditions of use, for any specific metal or alloy. Consideration of the ternary diagram of the U.S. patent quoted shows that a multitude of combinations are possible, without any particular indication of the correct selection. On the basis of the results obtained by the U.S. patentees with their 16 different solutions, ranging from mirror to matt finish, some typical solutions were tested in the author's laboratory, the test samples used being different alloys from regular production.

Fig. 1.—*Compact, in brass; unpolished-polished.*



The tests were made with leaded and lead-free brasses, nickel silver, with and without lead, tin bronzes, cupro-nickel, and copper. The polishing solutions had the compositions indicated in Table I.

The polishing results obtained on the different alloys are summarized in Table II, the capital letters relating to the quality or grade of the surface finish, as follows:—

A. Mirror finish, lustrous, high reflection;
B. Lustrous, internal structure easily seen, crystals bright;
C. Bright, internal structure increasingly apparent;
D. Surface attacked without polishing effect, crystals bright;
E. Surface attacked without polishing effect, crystals dull.

Some general remarks on the solutions tested may be of interest:—

Solutions 1 *and* 4. Fairly vigorous bath reaction; heavy escape of nitrous gases, discolouring the part of the sample outside the bath. Fairly good results were obtained with lead-free brass and nickel-silver alloys as well as cupro-nickel.

Immersion time: 15-30 seconds, in view of the high activity of the bath.

Solution 2. Slow reaction. Samples become dull or spotted. Nitric acid content too low (2 per cent).

Solution 3. Very active reaction and heavy gassing. The solution acts as a pickling solution rather than a polishing agent.

Solution 5. Rather slow reaction. This gave the best results, excepting on bronzes, which became dull. On lead-free brass, nickel silver and cupro-nickel, a practically mirror finish, Class A, was obtained. Little development of nitrous gases.

Solution 6. Lively reaction with development of nitrous gases; but results fairly good.

Solution 7. Results similar to the preceding. Nitric-acid content too high.

Considering that the above baths reacted in a lively manner at room temperature, no tests were made at higher temperatures. The results would probably not have been improved thereby.

Conclusions

1. *Type of Bath.* As a result of these tests on various alloys, it can be said that an appreciable proportion of nitric acid, but not exceeding 30 per cent is essential in the polishing solution.

Acetic acid, if present in suitable quantity, prevents the development of nitrous fumes.

Phosphoric acid is an important constituent. It forms a viscous film and to some extent plays the part of an inhibitor. A suitable percentage is between 30 and 60 per cent.

The other additions (HCl, NaCl) do not appear to play any important part. The water content, on the other hand, must be very low. Despite the great variety of solution compositions, the

TABLE II
Quality of Polish Obtained

Bath No.	Brass		Nickel Silver	
	leaded	no lead	leaded	no lead
1 & 4	C after 30 sec. D after 1 min.	B after 15 sec. C after 1 min. C after 5 min.	D after 30 sec. E after 1 min.	B after 30 sec. C after 5 min.
2	E after 5 min.	C after 15 sec. E after 5 min.	little or no effect	no perceptible reaction
3	C after 15 sec. D after 30 sec. E after 1 min.	B after 5 sec. B after 30 sec. C after 1 min.	D after 30 sec. D after 1 min. E after 2 min.	C after 30 sec. E after 1 min.
5	C after 15 sec. D after 30 sec. D after 1 min.	A-B after 5 sec. A-B after 30 sec. B after 1 min. C after 10 min.	C after 30 sec. C after 1 min. C after 5 min.	B after 1 min. B-C after 3 min. C after 5 min.
6	D after 30 sec. E after 1 min.	B after 15 sec. C after 30 sec. D after 1 min.	C after 30 sec. D after 1 min. E after 2 min.	C after 30 sec. D after 1 min. E after 3 min.
7	E after 30 sec. spots	B after 5 sec. C after 15 sec. D after 1 min.	D after 30 sec. D after 2 min.	C after 15 sec. C after 30 sec.

TABLE II (Continued)

Bath No.	Bronze		Cupro-Nickel	Copper
	Cu-Sn-Zn	Cu-Sn		
1 & 4	E after 1 min.	E after 1 min.	A-B after 30 sec. B after 1 min. C after 5 min.	D after 15 sec. E after 30 sec.
2	dull spots	matt appearance	good matt surface	C after 15 sec. D after 1 min.
3	B after 30 sec. C after 1 min. D after 2 min.	C after 30 sec. E after 1 min.	matt surface after 30 sec.	B after 15 sec. C after 30 sec. D after 1 min.
5	E after 30 sec. matt	E after 30 sec. matt	A-B After 1 min. A-B after 5 min. A-B after 10 min.	C after 30 sec. C after 1 min.
6	A-B after 30 sec. B after 1 min. B after 2 min.	B after 30 sec. B after 1 min.	B after 15 sec. C after 30 sec. D after 5 min.	C after 30 sec. D after 1 min.
7	A-B after 30 sec. B after 1 min. B after 2 min.	C after 1 min. E after 2 min.	C after 30 sec. E after 5 min. good matt surface	B after 15 sec. E after 30 sec.

essential ingredients are always acids or mixtures thereof.

2. *Results and their Interpretation.* A mirror finish, such as obtainable by mechanical means, was not achieved. Nevertheless, with solution 5, excellent results were obtained on homogeneous alloys. As soon as the material was heterogeneous, the internal structure became apparent, even on a lustrous surface. The particular type of solution suitable for each alloy needs to be investigated.

For specific purposes, chemical polishing will probably never replace the mechanical process. There are many applications, however, in which chemical polishing will be useful, *e.g.* watch and clockmaking and jewellery, especially since the process requires only the simplest equipment. Exhausters must be provided, however, to remove harmful fumes, and arrangements for cooling some baths, which heat up very quickly.

In estimating the working costs, regard will have to be paid to the fact that the life of the baths is quite short. They become spent very rapidly, tend to dissociate and are difficult to regenerate.

Finally, it must be pointed out that it is for the prospective user to decide whether chemical polishing is advantageous and economical or not, under the given conditions.

Electrolytic Polishing

The first serious investigations on electrolytic polishing were carried out in the United States (Battelle Memorial Institute) and in France (P. A. Jacquet); and, thereafter, the first patents were filed in these two countries. Since then, the problems of electrolytic polishing have received attention in more or less all European countries.

Electrolytic polishing techniques are based on the anodic dissolution of the surface of the work-piece to be polished under specific, controlled conditions. The method is not intended to replace mechanical polishing as the two techniques are *basically different*.

a b c

Fig. 2.—Polishing of complicated patterns in brass a—*unpolished,* b *and* c—*polished.*

Each method has its own advantages and disadvantages. In any event, the development of electrolytic polishing has represented a substantial advance in the technique of practical surface treatment: it enables particular properties of such surfaces, such as absorption, abrasion, frictional behaviour, reflectivity and emissivity, corrosion resistance, etc., to be studied *on the surface itself;* and it also enables different characteristics of the test-piece, particularly conditioned by its surface structure, to be more exactly defined—such as, internal friction, fatigue behaviour, capacity for deformation (plasticity), etc.

Polishing by mechanical abrasion produces a more or less extensive modification of the surface structure, by the formation of a "polished layer"; *i.e.* by removing the protuberances, and filling in the depressions.

The surface of a mechanically polished work-piece has an entirely different structure from that of the parent material. Mechanical polishing is always practicable, but more or less costly, according to the metal to be polished. Owing to the working of the surfaces and the "smearing" effect on the surface layers, irregularities in the material, such as blisters, cracks and scratches are not immediately apparent.

Electrolytic polishing, on the other hand, causes a dissolution or disintegration of the surface layer, the rate of dissolution being greatest on the projecting parts or surface protuberances. This, in fact, is what increasingly levels the irregularities of the particular surface. The condition of the surface after polishing, consequently, is representative of the condition of the metal immediately underlying the surface layer. The best results are obtained with metals having a uniformly regular rate of anodic dissolution after removal of the surface protuberances.

However, this is not always easily obtained, even in the case of high-purity metals. Depending on their orientation, the crystallites of the structure are more or less rapidly dissolved. In the case of a surface of excessively coarse grain structure, this becomes bared by anodic dissolution, *i.e.* a kind of etching effect is obtained, in which the crystalline structure becomes increasingly apparent. Similarly, a heterogeneous structure, inclusions, cracks, etc., produce effects conflicting with the desired results.

Electrolytic polishing enables surfaces to be produced with a very high degree of finish; and which, furthermore, shows the true character of the metal, *i.e.* its specific colouration. The polishing effect extends to all parts, while, *e.g.* in a relief stamping or moulding, the contrasts are diminished.

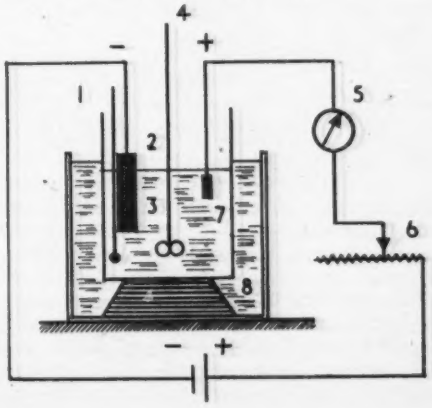
The polishing effect of electrolytic treatment depends on the following factors:—

1. Character and condition of the metal;
2. Structure of the metal;
3. Condition of the surface before treatment (scratches, inclusions, dirt or contamination, etc.).

The Technique

The methods used depend on the phenomenon of anodic dissolution. The work-piece to be polished is used as the anode, being immersed in an electrolyte solution, and subjected to specific, controlled voltages. The action of the electrolytic current produces gradual dissolution of the material. The protuberances on the surface are

Fig. 3.—Diagram of an electrolytic polishing installation. 1. *Thermometer;* 2. *cathode;* 3. *electrolyte;* 4. *agitator;* 5. *ammeter;* 6. *resistance;* 7. *cold water.*



more rapidly attacked, than the other parts; this produces an increasingly smooth surface finish: *i.e.*, a polishing action with varying degrees of brightness or lustre.

Polishing Equipment

Two systems are in practical use, *viz.:* one in which a series resistance is incorporated in the circuit (Fig. 3) and another with two resistances in parallel.

Conditions for High Polishing Effect

The influencing factors are very numerous, the following being the most important:—

Electrolytic cells can be of lead-lined wood, stainless steel, or porcelain and must be resistant to heating and/or cooling. The temperatures are controlled by duplex thermostats, and the jigs for the work-pieces are usually of copper.

Fig. 4.—Relief reduced, but high polish obtained.

Cathodes are normally of stainless steel, nickel, lead, copper; possibly of graphite. They must have at least ten times the surface area of the anodes (the pieces to be polished). Electrode spacing should not be less than 6 inches (150 mm.), but some authors specify 0.79 to 1.2 in. (20 to 30 mm.).

The work must be completely immersed in the bath, and, as far as possible, agitated or moved about therein, to prevent localized bubble formation. The bath temperatures should be kept constant.

Duration of Treatment

This depends on a number of factors, such as the degree of polish required, the surface condition of the work, and the nature of the material to be polished, current density, temperature, bath composition (to be controlled for density, viscosity and acidity). The most important factor, requiring the greatest attention is the *anode current density*, *i.e.* the ratio of current intensity to work surface area.

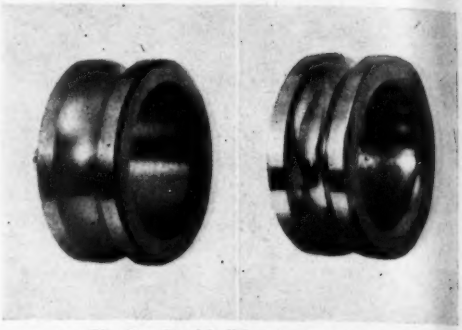


Fig. 5.—Steel ball-bearing inner races.

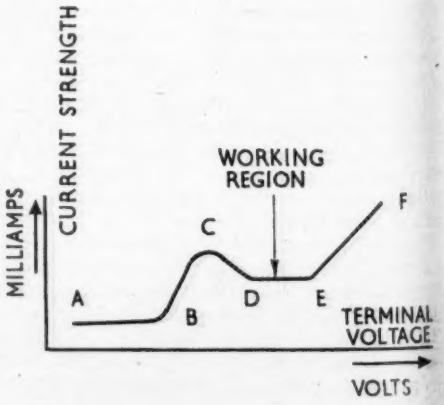
Excessive current densities intensify the surface relief by increasing the dissolution rate. The current density should also be maintained as constant as possible. A decisive factor, consequently, is the *voltage/current* ratio, which must be carefully controlled. The diagrams for a specific anode surface area must show the curve profile represented in Fig. 6.

As already indicated, the bath temperature must be as constant as practicable, since any temperature rise accelerates dissolution and increases the current density.

In the electrolytic polishing process, a relatively viscous and dense liquid film forms on the surface of the work in contact with the electrolyte, in which the dissolved substances accumulate. This film has a low conductivity, and its formation and properties are decisively influenced by the

(*Continued in page 192*)

Fig. 6.—Characteristic Current/Voltage Curve.
Segment A-B: start of attack.
B-C: anodic dissolution, dull surface.
C-D: start of polishing action.
D-E: full polishing action, bright surface.
E-F: end of polishing, bubble formation, surface dulled.



WORKS PRACTICE in Coloured Sheet-Iron Enamelling in Yugoslavia

by Ing. H. ANKERST*

A Paper presented to the 2nd International Enamelling Congress, Leamington Spa, 1955

Introduction

IT is not so much the intention in this Paper to deal with theoretical details of enamel colouring, or with coloured sheet steel enamels particularly as this subject is already well covered in the literature[1, 2, 3]. The chief intention is, to give a short and condensed account of actual observation and experience obtained with those kinds of enamel in the author's works over a period of years, especially bearing in mind certain practical measures that have had to be adopted because of the use of titanium superopaque enamels, which have considerably shortened and rationalized the previously used enamelling procedure.

The paper is divided into three main sections *viz.*: Coloured cover-coat enamels; a short account of observations with decorating-type white titanium enamels with various colours and with liquid bright gold; and some observations of special enamelling procedures, *e.g.*, the silk-screen process, or reverse printing on enamel using specially prepared vitrifiable colours.

I. General Practice with Coloured Enamels

By colouring the enamel, an improved appearance is produced on enamelware. This is very important in attracting the customer, who not only wants to buy goods of high quality, but also with an aesthetic appearance.

Until comparatively recently, it was normal practice in the enamelling industry to keep secret not only general operating procedure, frit compositions, etc., but also information relating to colour suppliers. But as scientific methods and results of enamelling techniques have advanced, the necessity for mutual collaboration among enamellists has become absolutely imperative; in addition collaboration is still more imperative between enamel shops and colouring-oxide manufacturers.

In the period prior to the superopaque enamels, especially the titanium enamels, enamellers were generally compelled, apart from the ground-coat enamelling, to give every article two cover coats. This practice was made necessary by the poor covering power of the old opaque-type enamels, which were mostly used for the white inside surfaces of kitchen-ware. The frits of these "classical" opaque enamels obtained their opacity, *e.g.*, by addition of 10 to 12 per cent of cryolite into the melt, plus additions of 4 to 6 per cent of opacifying oxides, *e.g.*, tin oxide, cerium oxide, zirconium oxide and the like, all materials with high refractive indices. The "classical" white opaque enamels had a limited covering power, which unfortunately could not be increased at will by simply adding more opacifiers, either into the melt or into the grinding mill, since that would have reduced the elasticity of the enamel and its gloss. It was possible however, to a certain degree, to improve the covering power of this type of enamel by finer grinding or by very carefully choosing the most suitable opacifier, *e.g.*, the American "Uverite" (U.S. Pat. 2,033-707) yielded very good results.

Therefore, in order to obtain good covering power, it was necessary to give all articles two cover coats, which had a total thickness of 0.25 to 0.35 mm. *not* including the ground-coat.

Similarly most works had to use the same double enamelling technique on the coloured outside surface. This practice was comparatively simple, and double cover coat enamelling yielded very good cover with all colours.

When dealing with pastel shades, the author usually obtained better results by making the first outside cover coat with a white opaque enamel, which helped to improve the covering power of the next pastel cover coat. In the same way, it is even possible to improve the covering power and efficiency of some intense colours, especially yellow, orange and coral red, *i.e.*, of those on the "red" half of the spectrum. This method also reduces the cost (coral red/cadmium—selenium/pigments are comparatively expensive) when compared with double cover coating in *the same* colour without a "white" undercoat.

With other coloured enamels, except for those that are based on self-coloured frits, the general rule was, to add into the grinding mill sufficient pigment, to obtain, after double coating, a total

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thickness of 0.25 to 0.30 mm. of enamel, of vivid colours, and with sufficient covering power. As for enamels based on self-coloured frits, *e.g.*, cobalt dark-blue enamel, or various types of black enamels, it was possible with thinner layers (about 0.15 mm.) to produce excellent results by double coating.

Double coating takes much more time, and it is also more expensive; in addition the comparatively thick layers produced give a surface that is easily damaged by slight pressure or bumping. On the other hand it must not be forgotten that, by the double coating technique it is nearly always possible to obtain more attractive, smooth, porcelain-like surfaces, and better resistance against abrasion.

When the superopaque titanium enamels came into use, and made it possible to work with a single cover coat new problems arose for colour enamelling, *viz.* to make the covering process short and cheap, and to adapt it to the enamelling of inside surfaces, from that time white titanium enamelled.

The advantages of titanium superopaque enamels are: improved covering power and reflectance; and much thinner layers of enamel are sufficient to produce perfect covering (about 0.10 mm. or even less). Thus, the necessary labour of slushing and spraying as well as the quantity of white cover-coat enamel used have been reduced by about 50 per cent; in addition the chemical resistance has improved, and the new enamels are non-poisonous. The reduced thickness of the enamel layers has also improved the elasticity of the articles.

Since with titanium white enamel only one cover-coat layer—and a rather thin one—is sufficient, it happened that many enamelling works did not find the correct technique at once; so, in enamelling the coloured outside surfaces the following procedure was adopted:

(*a*) Titanium frits which could withstand several fusions were used. The insides were coated with titanium white enamel, and the coloured outsides simultaneously, within the first operation. After fusion only the outside colour enamelling, was repeated.

(*b*) The titanium enamel was not applied until the second operation of enamel-coating. In order to avoid "overburning" of the ground-coat enamel which is left uncovered on the inside after the first operation, it was very delicately covered with ground-coat enamel during this operation.

(*c*) Both inside and outside were coated twice.

It is clear that, none of the above methods give a radical solution of the real problem. Although when using method (*a*) some enamel is saved, it should be apparent that, nothing has been saved by exploiting the capacities of existing equipment or on fuel and energy. The economy of titanium enamels combined with other colour enamels becomes significant only when a covering with coloured enamels is obtained such that a single cover coat is sufficient. Thus, it is imperative to improve the covering power of colour enamels. But that is not always simple and success largely depends on the type of colour enamel used.

Coloured enamels can be divided into three distinct types, *viz.*

(*a*) Transparent or selectively-absorbent coloured enamels;

(*b*) Non-transparent (opaque) or diffused-reflective coloured enamels;

(*c*) Saturated coloured enamels;

(*a*) The selectively-absorbent enamels include the types whose vitreous base, *i.e.* the frit, is coloured by melted-in colouring oxides, *e.g.*, cobalt blue frit, several black frits, and most of the jewellery enamels. In these frits that are absolutely transparent, the colour is provided by dissolved metallic oxides that selectively absorb the white light.

(*b*) The diffused-reflective enamels contain mixed-in particles of colour pigments that are not dissolved in the frit; they are added to the enamel in the grinding-mill. In this case, the colouring pigment must not be melted in the melted vitreous enamel. It should have as high as possible a refractive index. In enamels of this type, transparent, semi-opaque or opaque frits are used as the base. The latter types are made opaque when composing the basic frit mixture, by adding opacifiers, *e.g.*, cryolite, into the melt. The brighter the shade of the enamel is intended to be, the higher its opacity must be. Therefore, as a rule, transparent frits are used for intensive, darker colours, and opaque ones for brighter colours, *e.g.*, pastel-colours. Therefore, it is an obvious trend among manufacturers of enamel colours to create pastel colours that remain stable even in titanium enamels, which are very reactive towards enamel pigments; but this has not yet yielded any successful results on a larger scale.

(*c*) Saturated-colour enamels are between the two types just described. To this group belongs, *e.g.*, the chestnut-red enamel on a ferric-oxide base. Here the frit has to be saturated with ferric oxide in the first place, *i.e.*, during the melting process, and afterwards more ferric oxide is added to the grinding mill. It is only the Fe_2O_3 added to the grinding mill that works as a pigment; if the frit were not pre-coloured, a large part of it would melt to a dirty-green colour. There are several transitions between the chief types of coloured enamels.

With colour enamels made on the basis of self-

coloured frits, it is generally more difficult to obtain perfect covering by a single coating. An exception are *black enamels* which get their fundamental colour from the ground-coat enamels. Therefore, in such a case it is not a difficult problem to obtain a perfect black surface by a single, thin coating, and there are available excellent frits, that generally do not need any additions of black pigment into the grinding mill. These have a high gloss and good chemical resistance.

However, black enamels are still largely manufactured from coloured frits, with an addition of 1 to 2 per cent of black pigment into the grinding mill. Several colouring oxides are melted into the frit in order to obtain colours, *e.g.*, cobalt, nickel, ferric, chromium and copper oxides. As for the pigments added to the grinding mill, they are chiefly composed of the same oxides, in various combinations. Thus, by selecting carefully a pigment to be added into the grinding mill, it is possible to obtain satisfactory black enamels. Since high clay additions in black enamels interfere with the absorption of light—because of the gas bubbles developing in the enamel—it is recommended to reduce the clay addition, and to add up to 0.5 per cent of bentonite, which is a good sustitute for the missing clay, and does not cause the development of gas bubbles. If black enamels coloured in the grinding mill are used for rims and/or handles, the black pigments must not contain water-soluble chromium salts that might have remained in the pigment due to insufficient smelting, or more important, because of insufficient washing after smelting. In enamels that contain such pigments, the water-soluble chromates are given a chance to "wander" into the neighbouring enamel bisque up to distances of 10 mm., to cause ugly, yellow specks of colour.

When working with *dark-blue* enamels, it is more difficult to obtain a perfect and uniform covering by a single coating. The reason is that this cobalt dark-blue enamel is translucent, and therefore it can be efficient only in bulkier layers. If an attempt was made to opacify such an enamel, it would lose part of its aesthetic effect. Therefore, this type of enamel is normally applied as a double coating, especially on larger articles. Single coating could be effected by colouring the frits more intensively, and by adding a suitable setting-up agent; *e.g.*, $MgCl_2$, and hydrochloric acid have a good effect on intensifying the dark-blue colour, whereas sodium nitrite is especially detrimental as it makes the colour pale. This technique can be successfully used only with smaller articles.

The main representative of the saturated coloured enamels is the chestnut-red enamel based on ferric oxide, both melted-in and added into the grinding mill. This type of enamel has been very successfully used for the outside coating of kitchenware; with a single coating, it yields quite satisfactory covering.

To-day the majority of coloured enamels are based on the principle of diffuse reflexion and they are prepared by the addition of special pigments into the grinding mill, using opaque, semi-opaque, and transparent frits. These colour pigments[4] are generally inorganic metallic compounds. They are obtained by mixing single metallic compounds in varying proportions, then they are fritted, washed, dried, and ground. A good pgiment should meet the following requirements:

(*a*) good covering power, even at a low concentration;
(*b*) smallest possible particle size:
(*c*) the least possible solubility in an enamel solution (here the best seem to be colours of the spinel type, *i.e.*, compositions of metallic oxides with sesquioxides);
(*d*) the highest possible stability in fusing;

Generally, in colour enamels the author adheres to the principle of colouring transparent frits with intensive and "deep" colours. For brighter colours, opaque frits are preferred, and in certain cases—in order to improve covering with pastel colours—it is usual to add, in addition to the colour, an opacifier into the grinding mill, *e.g.*, tin oxide, Uverite, or sodium meta-antimonate. Most of the colour pigment manufacturers, when offering their products, usually give their customers fairly good instructions, and even compositions in order to enable them to use the materials correctly. Every new type of colour first has to be tested very carefully by grinding a portion of the enamel in a small laboratory mill, then fusing it on small test plates, under conditions as near as possible to the practical ones in the works. Only when this is done and has proved to be satisfactory, is the new colour gradually introduced into production.

Some Practical Hints

For *coral-red enamels* use pigments that are compositions of cadmium with sulphur and selenium. With these pigments the author has abandoned the use of transparent frits and now uses cryolite-opacified white frits with a high silica content. This has produced a superior covering, at the same consumption of pigment, better fusing stability, and an increased fusing interval. At the same time, a considerably lessened sensitivity of the enamel bisque when touched with hands moistened by perspiration has been noticed, and equally a lessened sensitivity of the colour towards setting-up agents; however these are avoided, preference being given to the addition of 0.1 to 0.2 per cent of

bentonite into the grinding mill. By this method " optical tearing " often experienced while using transparent frits has been eliminated. When working with smaller articles, it is not difficult to manage with a single coating. If the article is required to be coloured really vividly, it is recommended practice first to coat it with a thin layer of white enamel. followed by the coral-red enamel.

With the majority of *intensive colours*, such as for instance various green, blue-green, and brown colours, a considerable improvement in covering power has been obtained by a very slight increase in the additions of colour pigments into the grinding mill. The darker the colour is, the smaller are the necessary additions of colour pigments. Although enamels of these colours are very stable during fusion, here too it is a good principle to use the least possible amount of setting-up agent. Regarding setting-up agents, the best effects are obtained by potassium, magnesium, and barium chlorides. For these colours, only transparent frits of various types are used, which by their composition only slightly influence the shade of the colour.

Special attention is paid to the *new-blue enamels*. The pigments of this colour are based on cobalt, chromium and aluminium oxides, and are sold in a wide range of different shades. They are ground with transparent frits. It is an interesting fact that, these enamels must not be ground too finely, since exaggerated fine grinding has a rather bad effect on their fusing stability. It has even been observed that from the same enamel, and from the same mill charge, different shades were produced, when fusing the items in a continuous split-crown furnace at various perritt levels. This defect has been overcome by coarser grinding. Here too, the use of setting-up agents must be avoided. Enamels of this type can be adapted for single coating comparatively easily, providing quite satisfactory covering.

Bright green enamels (grass-green, Eau de Nil, etc.) require special practice. For these enamels, a cryolite opaque frit is used. For single coating as much as 6.5 to 8 per cent of colouring oxide has to be added. This practice tends to harm the surface gloss of the enamel, which might be spoiled by traces of harmful gases in insufficiently tightened muffles. These enamels have to be ground comparatively fine, otherwise the gloss of the enamel is reduced. Working with this type of enamel is difficult, since fine-ground enamels are more difficult to slush, and tearing may show up only too easily. The thickness of the enamel layer for a single coating should be 0.12 to 0.15 mm. Therefore, it is advisable to adhere as exactly as possible to the mentioned degree of grinding. As a setting-up agent very small amounts of potassium carbonate may be used.

Ivory and *cream-coloured enamels* are developed nowadays on the basis of superopaque titanium frits, so with these enamels there is no problem of covering. They are sold either as cream frits, manufactured with a rutile base, or with chromate additions fritted in. It is also possible to use white titanium frits and to colour them in the grinding mill, by adding suitable pigments. The latter method increases the ability to meet exactly the shade required. In working with cream-coloured enamels, it is of extreme importance to keep to standard working conditions from grinding to the final fusing of the enamelled article. The slightest variations in fusing might affect the colour obtained. As for setting-up agents, potassium carbonate or sodium nitrate give more yellowish shades, whereas potassium chloride or sodium aluminate make rather pale shades.

Conclusions to Part I

It may be concluded that, it is possible to intensify the majority of coloured enamels sufficiently, so as to use them for a single coating, with the proviso, of course, that all frits and enamel pigments are tested carefully and thoroughly. In addition to their quality, their price is fairly important when a decision has to be made regarding the type to be used.

II. Decorating Titanium Enamelled Articles

When the titanium superopaque enamels came into use, another important problem arose *viz.*: decorating of items enamelled with titanium white enamels(5). As compared with the " classical " opaque enamels, the titanium superopaque enamels have some quite different properties, quite apart from their higher covering power. One peculiar property is a considerably lower surface tension, *i.e.*, about 180 to 185 dynes per cm. as against approx. 250 dynes per cm. for transparent or opaque enamels. These values are measured according to Dietzel's method(6). So the " classical " cover-coat enamels show a far stronger tendency at a given volume to occupy the least possible surface, than do the titanium enamels. This fact has been proved by the following: when the surface of a titanium enamel bisque is marked with a coloured, for instance dark-blue enamel, after fusing a very sharp and hard mark is produced. The opposite effect is seen, when marking a coloured bisque with a titanium enamel: the mark spreads and becomes somewhat blurred, though the same stencil has been used in both cases, and the marks have shown the same shape and appearance on the bisque before fusing. Therefore titanium enamels are not suitable for marking (Fig. 1). Another

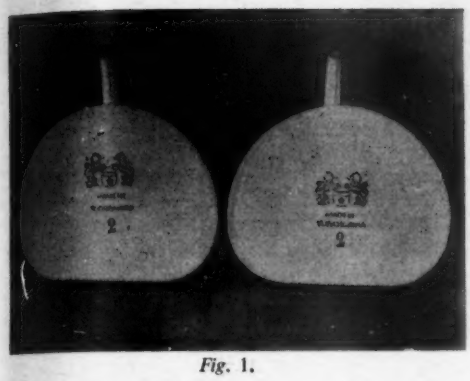


Fig. 1.

specific property of titanium enamels is their high chemical reactivity with enamel pigments. During the fusing process they react with the latter chemically and destroy them.(7) If to a titanium frit is added a new-blue pigment into the grinding mill, the result after fusing is an enamel of a yellowish-green to bluish-green colour, which is very unstable towards heat, heterogeneous, and full of white and coloured spots. Coral-red cadmium-selenium pigments added to titanium frits up to 1.5 per cent, are discoloured after the first fusion. If 3 per cent of the same pigment, that gives a good colour when used with " classical " frits is added, with a titanium frit only a pale yellowish-pink shade is produced. Even an abnormal addition of that pigment (7 per cent) yields a pink enamel after fusing, but an equally unstable one; under a microscope it appears very heterogeneous.

This reactivity of titanium enamels is noticeable even when a surface of already fused titanium enamel is decorated with another enamel of a different colour. This is done by spraying the coloured enamel on white enamelled articles, either free-hand or with a stencil. The consequences of the reaction can be seen after the fusing of the decoration coat, *viz.*: white dots on the coloured surface (Fig. 2). This defect is called a " breach " of the titanium enamel through the coloured one. This " breach " is most likely to show up, if a titanium enamel bisque is decorated before fusing with a coloured enamel. But if fused titanium enamel surfaces are decorated, and afterwards the " decorated coat " is fused separately, the " breach " will be less apparent, and less frequent. A large number of decoration-test-fusings, showed that the intensity of the defect depends on four factors:

(*a*) on the type of titanium frit;
(*b*) on the kind of pigment;
(*c*) on the coloured frit;
(*d*) on the fusing temperature of the decorated coat;

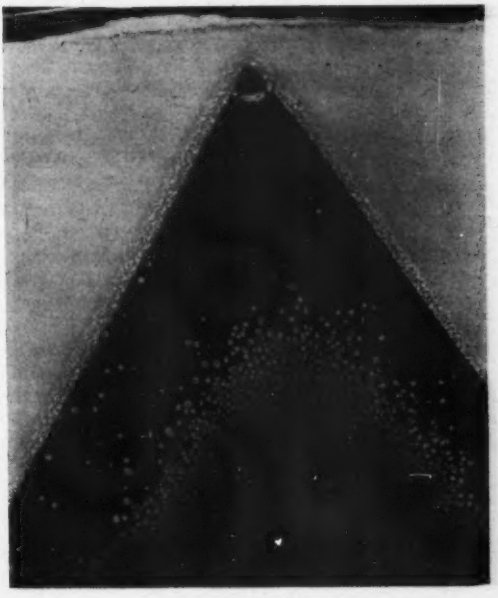
On the other hand, the intensity of the defect does not depend at all on the fusing temperature of the titanium enamel coat fused separately before decorating.

(*a*) Among different kinds of titanium frits, the acid-resisting, borate-containing superopaque types are especially reactive, particularly as their degree of whiteness grows, *i.e.*, the more Ti O_2 has been recrystallized in fusing. Borate-free, zinc-containing frits are considerably less reactive, and not acid-resisting. These are not suitable for the manufacture of kitchenware.

(*b*) Among all of the colour pigments in use, yellow cadmium sulphide has proved the best. When colouring enamels with this pigment and slushing or spraying them on the titanium enamel surface, the defect was not noticed even at very high temperatures (about 880° C.). Cobalt-blue, black and chocolate-brown enamels are relatively sensitive to the formation of the defect. Enamels of other colours yield better average results. The lower the fusing temperature of the decorated coat, the better are the results.

(*c*) The use of several transparent or opaque frits coloured by the same amount of the same pigment, causes varying degrees of fusing stability. It is not possible here to establish any general rules. High-melting-point frits often—but not always—produce better results than those with a low melting point; and opaque frits generally yield better results than transparent ones, pro-

Fig. 2.



vided the colour pigment can match an opaque frit.

(*d*) The best way to avoid the defect is, to lower the decoration fusing temperature by about 40° C. under the fusing temperature for titanium enamels. It is not enough only to shorten the decoration fusing time, without lowering the fusing temperature.

Boron-containing titanium enamelled articles, when decorated with liquid bright gold, show superior results to those obtained with " classical " opaque enamels. The decorations showed a better gloss, and a more vivid golden colour—whereas gold decorations on zinc-titanium enamels were rather dull and poor.

III. The Use of Specially Prepared Vitrifiable Colours for Transfer Printing on Enamelled Surfaces and for the Silk-Screen Process.

Transfer printing is used for smaller inscription boards, names, figures, etc. For that, a negative (mirror-like) print is first made with ordinary printers' ink on very fine, silky paper. Then the print is transferred to the enamel surface by a wetted roller; the enamel surface has to be clean and properly prepared in order to avoid surface tension. The water from the roller moistens the paper that repels the greasy printers' ink, and so the print (now positive) is transferred to the enamelled surface. The paper is then removed. The printers' ink acts only as a paste; it is burnt in fusing. A printed plate is dusted with a vitrifiable colour and then wiped with a piece of cotton. The colour sticks only to the printed places; elsewhere it is easily removed by the cotton. Then the article is fused and the colour is permanently fused on the enamel.

These vitrifiable colours are made of a mixture of low-melting point transparent frits and a suitable addition of colouring oxide. The mixture is then sintered at a temperature of about 800° C., and again finely ground, either dry or with alcohol. If the vitrifiable colours are intensively mixed with a screening oil of suitable consistency, a coloured paste is produced. This is used for screening, a well-known process by which it is possible to make cheaply and quickly inscriptions or decorations on fused enamel surfaces. This process can be done on a fairly large scale, using comparatively small quantities of paste. When the printing is done, the inscription or design is dried and then fused. In fusing, the screening oil evaporates and is burnt, while the vitrifiable colour joins the composition of the enamelled surface.

Using both printing processes on white titanium enamelled surfaces, it is possible to see the same defect as described in Part II, *i.e.*, the " breach " of titanium enamel through the coloured surface in the form of white dots. This also largely depends on the quality of the colouring pigment, as well as on the vitreous components. Among the pigments, cadmium yellow colours provide the highest, and cobalt dark blue colours the poorest fusing stability. This defect equally depends on the chemical composition of the white enamelled surface. It is not only titanium enamels that react with the colours. The same effects have also been experienced with a white powder enamel based on lead and arsenic; but the effect was absent on " classical " cryolite or antimony opacified enamels. Here again, the fusing temperature of the design is of paramount importance—it should not be too high.

Many of the vitrifiable colours, when dust-printed on enamel give comparatively pale colours, while the same colours as silk screening pastes yield intensive and vivid colours. The reason for this is that the colour is agglomerated within the paste—under the influence of the screening oil—into larger particles that occupy the surface densely, whereas in the transfer-printing process, the minute, dry colour particles stay rather apart. Under the microscope the pale, dusted transfer-prints look very sparse and torn and the screened prints look much more compact and densely coloured. An improvement is made if the " dust " of vitrifiable colour is moistened before using it, with a very small amount of screening-oil (which, however, soon dries and thus reduces the effect), or with a drop of glycerol; the colour effect is in most cases improved considerably and immediately.

Acknowledgements

The author would like to thank several firms that have generously supplied samples of their products.

Blythe Colour Works Ltd. of Cresswell, Stoke-on-Trent,
Ferro Enamels (Holland) N.V., of Rotterdam,
" DEGUSSA " of Frankfurt/Main,
Farbenfabriken Bayer of Leverkusen,
Schauer & Co. of Wien-Atzgersdorf,
and many other firms, some of whom provided research facilities in their laboratories.

Thanks are also due to the Management Board of Tovarna emajlirane Posode of Celje, for permission to publish this paper.

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A Student's Guide to Examination Courses in Metal Finishing

Compiled by A. ALEXANDER

In this series of articles, concluded in this issue, an attempt has been made to assist actual and intending entrants for the City and Guilds Certificate Examination in Metal Finishing to apply their knowledge to the answering of examination questions in the most effective manner. As the whole structure of the educational system in this field is at present subject to overhaul, this final instalment is devoted to an appraisal of the present situation and some views on its outcome.

(*Series concluded from page 34, January, 1956*)

IN the previous articles in this series, the City and Guilds Course for Operators and for the Intermediate examination in Metal Finishing was discussed. As at present drafted the syllabus calls for a further two- to three-years' instructional course followed by a final examination which, if evidence of proficiency in certain ancillary subjects can also be supplied, carries with it a technological certificate.

It is, however, understood that there is likely to be a change in this procedure and it is felt that at this juncture it would be unsatisfactory to consider the final syllabus as it now stands.

At the present time there is some considerable difficulty in attracting young people into the industry, largely due to the fact that there is no recognized apprenticeship scheme in existence (although many of the larger firms have their individual schemes) and that there is no guarantee of status when a boy has served a certain time or reached a certain degree of proficiency. This state of affairs is causing some concern because it is essential that there shall be a supply of qualified metal-finishing personnel who are capable of operating the various plants in existance or being installed. In addition, with modern processes which enable higher outputs to be obtained from vats of a given size, it becomes increasingly necessary to have capable personnel available who can understand and control the processes in use.

This matter is receiving attention from some of the trade bodies concerned and arrangements are being discussed for producing an apprenticeship scheme which can be recognized by all the industries concerned and also by the Ministry of Labour.

It is supposed that the average apprentice would enter the industry on leaving school or shortly afterwards and that many of the boys concerned would be primary school boys, and would leave school at the age of 15. These boys would sign up for a five-year period which should allow them to qualify either at, or possibly slightly before, the age of 21.

It is suggested that a boy signing as an apprentice should be employed in a plating shop which at least deals with all the commoner metals, and that arrangements should be made to move him from one section to another so that he can obtain the necessary practical experience. It is probable that the Committee concerned will lay down the requirements for this part of the training and that firms taking apprentices will have to produce some kind of evidence to show that they have the the necessary facilities. There is little doubt that most of the "outplating" shops would have such facilities but certain manufacturing shops may deal only with one or two metals, for example zinc or cadmium, and in such cases would not qualify unless it were possible to share apprentices with another works plating, say, nickel and chromium.

While five years in an industrial shop would undoubtedly give a boy considerable insight into the "art" of plating, it is felt that something more than this would be required if the boy is really to understand the processes he is using. Such knowledge might, of course, be supplied by the personnel of the plating shop but in many cases this would be difficult to organize on the score of time alone, as it could hardly be expected that a qualified plater under whom an apprentice was working, would be able to give up some of his own time to instruction, neither would it be possible, normally, for time to be spared for this during working hours. Where suitable courses of instruction are available at technical colleges, the apprentices should be released for part-time study, say, for example, one day per week. In addition, he should be encouraged to take some courses in his own time.

It is understood that at the present time a course somewhat similar to the operators' course which has been already dealt with in these pages, should be taken by the apprentice and that at the conclusion of this course he should take an examination. If he is sucessful in this examination this fact would be endorsed on his apprenticeship papers and such papers would be recognized by the industries concerned; thus a boy who completed the courses and served the

necessary time in the plating shop could obtain a higher rate than an unqualified man applying for a position in the same shop.

It must, of course, be realized that there are several difficulties in operating a scheme of this type. First, not all plating businesses are situated within reasonable distance of the necessary educational facilities. Second, some excellent platers are "examination shy"; *i.e.*, a boy may learn the practical techniques required quite well and be able to operate the various processes, but he would feel at a considerable disadvantage when faced with an examination, particularly a written examination on theoretical subjects. It is possible that in certain cases an oral examination could be arranged, but it is believed that this might be difficult under the present conditions.

The author suggests that what is required is a permanent committee dealing with the apprenticeship scheme. This committee, appointed and recognized by the various industries concerned, would keep a check on all apprentices entering the industry and in cases where special difficulties were encountered, would do its best to eliminate them. The committee, for instance, might interview candidates, particularly those who have been unsuccessful in written examination, if their employers felt that they were suitable people to be passed out. This committee could also specify the facilities which a firm must provide and no doubt could, from time to time, examine the scheme to find out how it was working and whether the various apprentices were given the full opportunities to acquire the necessary knowledge and practice.

Employers' Requirements

It may be interesting at this point to consider what an employer requires in a man who applies for a position as plater, because this will undoubtedly effect considerably any training or instructional courses. Apart from questions of character, that is to say, honesty, willingness, good time-keeping, etc., it is felt that a man who is to be employed in a plating shop, presumably taking charge of one or more plating vats, or possibly of an automatic plant, should have a considerable amount of elementary knowledge and also experience in operations that he is to carry out.

In the first place, it is desirable that he should know something about the plant itself which he has to operate. Many platers, for instance, seem to have little or no electrical knowledge; they may have some vague idea of the electrical circuits on the vat itself and how to connect the various instruments and what these instruments show, but they have usually little or no idea as to the working of a dynamo or rectifier. It is felt that a plater should have a clear idea as to how these pieces of plant operate and how they are controlled and maintained. Thus, if a plater is aware that a rectifier when overloaded becomes hot and he notices the rectifier in the shop getting hotter than it should be, he may be able to prevent a serious breakdown which would cost his company a considerable amount of money. Some knowledge, therefore, of alternating- and direct-current circuits, is essential, if a man is to be of value to the company which employs him.

It is also very desirable that the plater shall have some elementary knowledge of chemistry; at least he should have sufficient knowledge to be able to understand a chemist and to know the meanings of the various terms that he uses. Thus, it is often found that a plater, called upon to estimate the pH of a plating solution, knows how to do this by means of test papers or comparators, but does not know the meaning of the figure he obtains. In a modern plating shop it is essential that both chemist and plater should work together hand-in-hand in the processes which they have jointly to operate. It is, however, difficult to get a chemist to phrase his conversation in such a way that it can be understood by someone who has no knowledge of chemistry. In most sciences there are a number of specialized terms which in fact, act as a kind of shorthand and enable people to put over their ideas very much more quickly than if they had to explain what they wish to say in ordinary language. Thus the chemist can hardly be blamed for using the jargon of his profession because if he did not do so it would take him very much longer to explain what he meant. It is desirable, therefore, for the plater who is to work with him also to learn this jargon, if it may be called such, so that he can, in fact, not only understand what the chemist is talking about but use the same terms to put over his own ideas on the subject in question.

One of the most important things that a plater must learn is how actually to handle the work in the shop. It may seem comparatively easy on getting a box of components to be plated, merely to hang them in plating vats, turn on the current, leave them for a stated time and then take them out, but what anyone knows who has been associated with the industry is that the method of setting up the work and preparing it is of very great importance, and generally controls the success of the operation. Thus a man given a box of work to be nickel plated must know in the first place, whether the articles are to be dealt with in a still vat or in a barrel; if they are to be placed in a still vat, how will they be suspended, what preliminary cleaning and pickling

processes are to be applied to them in order to obtain a satisfactory adhesive deposit, and how are they to be put through these processes and placed in the plating vat?

It is this knowledge which distinguishes a qualified plater from a labourer.

Such knowledge can only be acquired by working in a plating shop for a period and actually seeing how the work is dealt with. It is not possible to teach it by means of a blackboard and a piece of chalk or to learn it from a text-book. While the various compositions of the different solutions used for preparation can be written down and learned if necessary, and also the cycles of operations required to prepare a given metal for any given plating process, the actual operation of a manual plant requires a certain amount of dexterity which comes largely with practice. Also a qualified plater must be conversant with the appearance of the surface of the article which he is plating, during the various processes which are being carried out, so that he can tell at any time whether these processes are operating successfully. Unfortunately, in the present state of knowledge it is not possible completely to control a plating or cleaning solution in the laboratory. Small quantities of impurities which cannot be estimated, at any rate under industrial conditions, will often have a very large effect on the processes being carried out. An experienced man should be able to observe the appearance of the article and to see at once whether the process he is operating is working satisfactorily. Often he is able to tell that there is something wrong before the trouble has got to such a state that it causes a rejection of the plated article, and men who have this capability are extremely valuable to the firms that employ them, because they can prevent trouble, loss of time and money. The ability to do this depends largely on the powers of observation of the individual concerned, together with the experience that he has had. If, when trouble develops on a tank that he is operating, he notices the signs shown by the articles being treated, he will again when observing similar signs, remember the cause of the previous trouble and be in a good position to rectify it before any great financial loss has been caused.

It is, of course, difficult to ensure that an apprentice will obtain the necessary training or that he has, in fact, obtained it. It is probable that the best qualification he can have is a satisfactory report from his employer, but this may be open to some doubt because there will undoubtedly be employers who might give such a report without satisfying themselves that the apprentice in question had really benefited by the training that he had been given. Ideally it would be desirable to give an apprentice some type of practical examination; for example, he might be shown certain specimens and be asked what was wrong with the processes by which they had been treated, or he might be called upon to produce certain coatings with given facilities. It is not easy, however, to see in practice how such an examination could be organized. While it is comparatively easy to run an examination on a theoretical course of training, it is undoubtedly difficult to run one on a practical course, and the difficulty is increased by the fact that in plating a considerable part of the success of the operation depends on the make-up and state of the solutions concerned. An apprentice required to nickel plate a piece of steel could hardly be expected, during the period of his examination, to make up and condition all the necessary solutions required for the purpose so that he would have to be given these and if these were not working satisfactorily, he could not produce a satisfactory job, whereas, if they were, in fact, working correctly he might have little difficulty in doing so and it would not be a true test of his capabilities. Thus, for example, an apprentice bricklayer can be given a certain amount of bricks and mortar and told to build a structure according to a drawing supplied. In such a case it is comparatively easy to organize a practical test, but as mentioned above, plating-shop conditions would be very much more difficult and it is doubtful whether a test of any great value could be arranged on such lines.

In spite of such difficulties, however, it would appear that an employer requiring plating-shop operatives, would be much more likely to obtain a satisfactory individual if he took one who had served an apprenticeship arranged on the suggested lines, than one who had not, even if the latter had worked in a plating shop for some considerable time. An ordinary plating-shop operator who obtains a job as a plater or assistant plater without previous experience, may work for many years on one or two specific processes and may obtain some considerable skill in carrying these processes out. It will usually be found, however, that he has little basic knowledge for what he is doing, he is usually unable to converse freely with either chemist or engineer, and that when taken away from the shop in which he has been working and placed under somewhat different conditions in another job, he is often completely lost and unable to carry out the processes with which he was conversant because, in fact, he does not know the basic requirement of these but has only been operating them under the instruction of others. This has been quite a

common experience in industry which has lead to considerable disappointment, both to the firms and the individuals concerned and it is felt that it can only be rectified by making sure that youngsters entering industry are first put through a proper course of training before being tied down to specific jobs.

The principle requirement of an employer is that a man which he engages shall be able to carry out the required work under the conditions which he is able to provide, or, if it is impossible to do this work under these conditions, that the man must be able to state clearly and accurately how these conditions must be varied to enable him to obtain the required results. When a man is able to do this he should be regarded as a qualified plater and his status in industry should be similar to that of any other qualified tradesman who has served a recognized apprenticeship. Too often, however, especially in the larger firms, the plater is not given this status and is looked upon rather as a somewhat superior yard labourer instead of a tradesman who ranks with the turner, fitter or other individual of this type. A properly qualified plater requires just as much knowledge and experience of his subject as other tradesmen do of theirs.

The Status of the Electroplater

The question of status is undoubtedly one of considerable importance. It has been shown by those concerned with industrial psychology, that a man's status is often more important to him than his actual pay and that a man who has obtained a certain status in some particular trade would rather continue in that trade at a lower rate than take on some job requiring no qualifications, even if he were able to earn more money by doing so. It is, therefore, apparent that in order to induce boys to serve an apprenticeship in metal finishing, it will be necessary to guarantee that if they pass through this satisfactorily, they will attain a certain status in industry generally, and be recognized as a tradesman. Such recognition must be given not only by the plating firms themselves, but by all companies employing platers. At the present time it is probable that three-quarters of the plating carried out in this country is carried out by manufacturers who have plating shops employing anything from two or three to perhaps 100 platers. These platers often find themselves at a disadvantage both from the point of view of their status in the company, and their rates of pay, when compared with other skilled craftsmen employed by the same organization. They are usually in a minority and generally have little opportunity of making their feelings felt, although their value to the organization in question is apparent, since many of the parts made by it will require some type of finishing and unless this is done and done economically, the article concerned is valueless. It is hoped that an apprenticeship system of the type outlined, will produce an individual who can be recognized by the various industries concerned and it is also hoped that an industrial body representing these industries can be formed and can agree to take the necessary steps to see that such recognition is given. Unless this is done it is improbable that many apprentices will be forthcoming.

Further Education

While a boy who has entered industry at 15 or 16 and served a five-year apprenticeship term and who has also successfully passed the required examinations on the theoretical courses may be considered to be a qualified plater, it is hardly expected that he would be qualified to take charge of a plating shop in the capacity of foreman or manager. First, he would not be old enough to have acquired the necessary poise and personality and, second, the required courses which could be fitted into the apprenticeship period would not be sufficient for him to acquire all the necessary information to enable him to carry out his duties satisfactorily. It would appear, therefore, that some additional course will be necessary, similar to the final City and Guilds course as it exists today.

What knowledge is required by a man who has to take charge of a large modern plating shop, either an outplaters shop or a shop attached to a manufacturing business? Apart from thorough knowledge of the processes involved and a certain amount of background theoretical knowledge to enable him to discuss the various problems concerned with chemists, engineers, etc., such a man must have some considerable knowledge of costing and organization.

It must be remembered that one of the main differences between the laboratory and the shop floor is that in the latter case the various processes employed must be operated at a profit. This means that whoever is in charge of them must be aware of what the processes are costing to operate and be in a position to reduce costs wherever possible. It is likely, also particularly in large factories, that there will be a cost department and that the man in charge will have to work closely in touch with the factory cost accountant. A basic knowledge of the methods employed for assessing factory costs, therefore, is essential.

The man in charge of the shop must also have some knowledge of how to estimate his labour and a basic knowledge of certain of the modern methods of time and motion study and work

study would undoubtedly be helpful in many cases, particularly in large organizations.

This man may also be required from time to time, to advise the management on the installation of new plant and changing processes, etc. He must, therefore, be capable of laying out plant, making, and particularly reading, layout drawings and in certain cases, being in a position either to design, or at least to advise on the design, of special plant for some particular processes.

It it quite apparent, therefore, that a man who has to take charge must have a considerable amount of training over that which could reasonably be given during his apprenticeship.

Assuming that a boy has served his five years and at the age of 21 has passed out as a qualified plater. He is then faced with the question of how to obtain the further knowledge necessary to fit him for a charge job. It is, of course, probable that only a percentage of boys who complete their apprenticeship will go further, but it will be necessary to provide some facilities for those that wish to do so. Ideally, some type of National College should be provided which would give a suitable course, lasting over, say, two years, perhaps for six months in the year, and at the end of this course award a National Diploma to a candidate who has successfully passed through the course and has satisfied the College that he has attained a certain proficiency in the various subjects. This may one day be provided but it seems unlikely at the moment that there would be sufficient students to justify the setting up of such an organization. It is probable, at any rate for a period, that some other method will have to be sought by which young men who do pass through their apprenticeship or who do obtain some other suitable qualification should be able to obtain the necessary training and knowledge. One method that has been suggested is that some of the technical colleges should run a "sandwich" course. This involves the student attending selected parts of various courses, such as chemistry, metallurgy, machine drawing, electrical engineering, works' organization, etc. Such courses could probably be organized by some of the technical colleges so that the student who was able to give up the necessary time, would be able to learn sufficient of the subjects concerned for the purpose required, without the necessity of taking the full course, which would undoubtedly include a great deal of material not required by him.

Such courses, if they could be organized would undoubtedly fill, or help to fill, the gap between the preliminary training and the final qualification.

There is no doubt, however, that a young man who had served his time in the shops or who had taken a college degree or National Certificate, would have to spend some considerable time to qualify for a full certificate in metal finishing. This may present some difficulty unless industry generally is prepared to co-operate and not only release the individual concerned for the necessary period of time but even to assist in maintaining him and paying the tuition expenses. In some industries this has been done already but there is always a difficulty that the firm concerned may have to spend a considerable sum of money only to find that at the end of the course or shortly after, their employee leaves their service for a better job. It is difficult to bind a man to stay with a firm for any period of time and even if some sort of contract or agreement is made, it is often impossible to enforce it. One method that could probably be adopted, would be to make an advance to the individual concerned to carry him through his study period on the basis that this would have to be repaid by the difference between the salary paid him and the increased salary which he might expect when the money was paid off. If he left before the period of time over which these repayments extended, he would have to refund to the firm concerned the balance outstanding.

It is envisaged that a man would probably require about two years of training, during which time he would probably spend about 6 months in the training establishment for full-time education and 6 months in the works following his normal occupation. Thus an employer would lose his services for a total period of 12 months spread over two years, and would have to pay him for this period to enable him to take the required courses. This would mean a cost to the employer of anything between £1,000 and £1,500.

At the same time, industry must realize that unless some such steps are taken it is unlikely, in a few years time, that they will have the required personnel to run their finishing departments efficiently. It has been suggested that with the present trend towards mechanization most of the finishing of the future will be done by automatic machines and that all that will be required is possibly a chemist to analyse the solution, although even this might be mechanized in certain cases. Unfortunately, however, it is extremely improbable that such ideals will be realized. While many of the ordinary operations can be mechanized, it has usually been found that as the plant becomes more and more highly complex, more and more skilled personnel are required to operate it. If, in a manually operated plant the plating vat containing three or four hundred gallons of solution

fails to operate properly, the loss to the business may be in the vicinity of £2 or £3 per hour, while the vat is out of commission. If, however, a large automatic plant develops trouble and has to be stopped, the loss may be anything from 10 to 50 times as much, and it is, therefore, very essential that the people operating this plant should be fully qualified so that such stoppages do not occur. In some businesses also the results of failure of plating plant may be even more serious, since the articles being plated may be going directly on to an assembly line and if the plant fails to operate the whole assembly line may be brought to a standstill, involving the cost to the company concerned of several hundred pounds per minute. If these facts are brought into perspective it should be clear that industry would be well advised to consider carefully what training is required to run such plants efficiently and to make certain that their personnel are fully trained and competent even at the expense of several hundreds of pounds. It will be seen that it is far better to spend, say, £1,000 to train a man to take charge of a plant of the nature described than to shut down a modern assembly line for even half an hour.

In the past the City and Guilds of London Institute has been the examining body for metal finishing and has provided an elementary and an advanced examination. If, however, training for the more advanced type of work is to be undertaken by technical colleges or, as suggested, ideally by a National college, then it may be more logical for some type of diploma to be issued by these bodies which could take into account not only the candidate's knowledge of metal finishing as such, but also the various ancillary subjects which he has taken. It was pointed out above that a man, to qualify for a charge position, must have a wide knowledge of a considerable number of subjects, although in many cases it may not be necessary for him to take the full course provided. It would be somewhat difficult for an outside examining body to deal with a situation of this type, since it would mean that it would have to stage a number of examinations on the various subjects concerned, or alternately a very complex paper involving all these subjects together. In many cases, therefore, it might be better for the technical institution concerned to satisfy itself that the candidate had taken the necessary courses provided by them which could no doubt be done by a short examination after each part of the course, based on the course in question. This would involve a number of short examinations spread over the suggested two-year period and if the candidate successfully passed these he would then qualify, whereas if he did not, he would have to re-take only that particular course in which he had failed. A candidate would then be assessed on the result of these examinations, together with some allowance for the attendance and general standard of the work during the term.

While such an arrangement would be comparatively easy to organize if there were one central educational body, the type of National College which has been set up for certain other industries, it might be more difficult to arrange if the courses were taken on the "sandwich" principle.

The setting up of any type of certificate is always rather a difficult problem. If the award is made too difficult, many possible candidates are frightened off and a large proportion of those who do, in fact, endeavour to obtain it may fail, even when they have attained a generally satisfactory standard of knowledge. If, on the other hand, the award is made too simple, then it becomes practically valueless and many may feel that it is not worth obtaining or, in fact, if they do obtain it they may find it is of little help to them.

Undoubtedly a suitable qualification should be given to a student who takes a course of the type described and satisfies the examiners that he has reached the required standard. This qualification must be recognized by industry, *i.e.*, the average firm must agree to pay a man who had attained it a higher rate than one who has not, and to consider him preferentially for advancement to a charge position. Unless industry is prepared to recognize such qualifications, it is apparent that any young man entering it will not bother to qualify and such platitudes as "It will doubtless be of use to you in later life" are unlikely to attract a man to give up a considerable proportion of his time to take on a complicated course of study even if he does not lose finally by doing so. Ideally, also, a qualification of the type envisaged should carry with it some type of insignia award, that is to say, a set of letters which the man may use after his name. A man who has either served his apprenticeship or taken some type of official certificate in chemistry or metallurgy, and then taken a further course of study in metal finishing and allied subjects to attain the standard of proficiency required for a charge position, is undoubtedly, as highly qualified in his field as a man who takes a college degree. He often finds himself, however, considerably at a disadvantage, particularly in large organizations, when dealing with a man who has passed through college and taken, say, a B.Sc., in chemistry. This latter man considers himself to belong to the professional class but does not recognize the unqualified man who he often considers to be

little better than a labourer. There is little doubt, therefore, that the higher qualification should enable a man to join a professional institution which would put him on a level with chemists, metallurgists or engineers in the organization in which he works.

As has been previously mentioned, it is understood and some action is being taken, to produce a satisfactory apprenticeship programme which it is hoped will be recognized by the major industries concerned with metal finishing. It is hoped, also, that when this has been completed some attention may be given to the more advanced education and the setting up of a suitable qualification for those who have attained the required standard. No doubt the committees concerned will, in due course, produce a syllabus of what they consider is required for this and when this has been done, it will no doubt be possible to extend these series of articles to deal with the the various questions involved. While, ideally, the student should attend an educational establishment for some part of his training, it is realized that in many localities such establishments or courses will not be available and that some provision will have to be made for those who have to study privately. While it is admittedly by no means easy to qualify by doing this, it is undoubtedly possible, and in the past, of course, many people have done it. Suitable text books exist covering most of the subjects required and it is hoped that other books or articles will be written to cover those subjects which are not at the present moment represented.

It may be hoped that some provision will be made for those people who are unable to attend a recognized college, although in the case of the advanced qualification, if full-time courses were attended for a period during the year, it should be possible for the student to be temporarily boarded at a place where such courses were available.

Organic Coatings

So far this series has been devoted entirely to electroplating, with its ancillary subjects. However, it must be remembered that the application of organic coatings, for example, paints, enamels, etc., is also a part of metal finishing and that this must be kept in mind when considering both apprenticeship courses and the more advanced courses for technologists. The formulation and production of paints is largely a matter for the chemist, but at the present time there is no well-defined body who deals with the application of these materials to the metal surface. It is sometimes held, particularly by electroplaters, that these processes are comparatively simple and that anyone with a few-hours' training can operate a spray gun or similar piece of apparatus and satisfactorily paint a metal article. This, however, is doubtful and there is considerable evidence that industry today is wasting a large amount of money due to the lack of proper training of those who are applying the various paints and enamels supplied to them by the chemist. In some cases, the foreman of a finishing department may be required to know both sides of the business, that is to say, he may be in charge both of electroplating shop and of spray shop. In many cases also, a technologist employed by a large industrial organization may have to deal with all types of processes. It seems probable, however, that an apprentice would be apprenticed only either to a plating shop or a spray shop, and although during the term of his apprenticeship he might be given some elementary instruction in the other processes, he would serve his time directly on one side or the other and would qualify either as an electroplater or a sprayer. While a sprayer would not be expected to know much about the formulation of the various paints that he used, or how to produce them, he would be required to know the various types of materials available and together with their advantages and disadvantages for specific purposes. He would also be required to have a thorough knowledge of the various methods of application and also how to prepare the surface on which these materials were to be applied, so as to obtain satisfactory results. Thus, on being presented with a certain object and being required to obtain a certain coloured finished on it, he should know how to clean and prepare the article, what type of undercoat is required, the best type of paint or lacquer to apply, the number of coats, and the stoving or baking treatment and also the maintenance of the plant used to apply the paint. In the case of a spray gun, also, some manual dexterity is required to obtain satisfactory results, the correct mixing and thinning of the paint, the maintenance of the spray gun, the adjustment of the gun to give the correct spray and the method of holding it to ensure the most economical and satisfactory results all have to be learned and practiced. It should be remembered that today industrial paints and enamels are extremely expensive. Holding down the trigger of a spray gun can quickly disseminate a few pound's worth of paint in a short time, and if the gun is not operated to the best advantage, an operator may waste almost as much as he applies, even if the work he does is satisfactory. Once again, therefore, industry would be well-advised to make certain that the necessary training facilities exist, not only for those going into the plating shop, but

(*Continued in page* 192)

TABLE III
Bath Compositions for Electrolytic Polishing

H_2SO_4 Sulphuric acid conc.	H_3PO_4 Phosphoric acid conc.	Various additives	Temperature	Anodic current density	Voltage	Remarks
72-75%	—	—	40-48°C.	—	—	German silver
14-16%	62-65%	—	45-55°C.	16-25 amp/dm²	—	German silver
—	70%	10% CrO_3	55-60°C.	20-40 do.	—	Alpha brass
—	—	56-60% Pyrophosphoric acid	50-60°C.	20-30 do.	—	Copper
—	50%	—	—	25-60 do.	1.5-1.8 volts	Copper
—	25-55%	—	—	—	1.1-1.8 do.	Copper and brass
—	430g/litre	—	Room temp.	13-15 do.	1-2 do.	Brass 70/30
—	990g/litre	—	—	2.5-3.0 do.	2 do.	Brass 67/33
—	530g/litre	—	Room temp.	9-11 do.	2 do.	Brass 60/40
14%	59%	0.5% CrO_3, rest H_2O	40°C.	1-45 do.	—	Copper and brass
—	10-90%	1% CrO_3, max 25% H_2O	50°C.	10-80 do.	—	Copper and brass
—	825 cm	175 cm glycerine	20°C.	—	8-10 volts	Copper and brass
—	50-60%	15-25% glycerine, 10-20% H_2O, 2-3% H_2O_2	15-35°C.	20-30 do.	—	Copper and brass
—	45-55%	25-35% glycerine, 15-25% H_2O, 2-5% H_2O_2	50-60°C.	—	—	Copper and brass
5-15%	60-75%	0.1-7% CrO_3, 13-27% H_2O	37-57°C.	16-36 do.	—	Copper and brass
10%	—	90% H_2O, 3-75 g/litre oxalic acid	70-75°C.	—	—	Copper and brass

Chemical and Electrolytic Polishing of Non-ferrous Metals

(*Continued from page 178*)

characteristics (conductivity, power of dissociation) of the products of electrolytic action.

In many cases, these are complex, soluble salts, which may be considered as a favourable development. Hence, phosphoric, perchloric, or cyanide baths are preferred.

Bath Composition

A multitude of different bath compositions are available, all suitable for different metals. It is, therefore, difficult to single out any particular bath or baths. It is only proposed to mention some, particular bath types, as at present used in the U.S.A. or in Europe, for the electrolytic surface treatment of metals. Table III gives a brief survey of the most important bath types in present use.

This table only lists baths for non-ferrous metals, but it must be pointed out that steel and iron (particularly the stainless steels) can be successfully treated by this method. For this purpose, a similar multiplicity of baths of similar composition exist. The additives which are even more numerous and produce complex, soluble salts, include citric acid, lactic acid, acetic acid, tartaric acid, oxalic acid, etc.; and the proportion of sulphuric acid is likewise higher.

Conclusion

Even careful weighing of the advantages and disadvantages of this technique gives no reliable guide to a generally valid conclusion. In nearly every case, the prospective user will have to proceed by trial and error.

At the present time, electrolytic polishing is regularly used in the manufacture of the following articles: railings, buttons, handles, writing pens, surgical and dental instruments, table cutlery, toasters, kitchen hardware, screws, toilet goods, watch and clock parts, jewellery, etc.

Rational polishing treatment of small articles is still somewhat impeded by the high current densities required, which make tumbling in drums impracticable.

Finally it should be pointed out that, to obtain a really high grade finish, the material should be of the highest possible purity, and of a fine and regular grain structure. Lead-free brass alloys are the most suitable. In any event, the metal worker should get in touch with the metal suppliers before envisaging the introduction of electrolytic surface treatment methods.

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also those who are required to take charge of and even to operate a spray gun.

It is felt that at the present time since the training facilities are being overhauled, it would be difficult to continue an educational series in these pages. It is, however, hoped that at an early date some decisions will be taken which will enable the drafting of suitable syllabus for the various qualifications. When this has been done, it will no doubt be found possible to continue the series to cover these.

THE INSTITUTE OF METAL FINISHING

1956 ANNUAL CONFERENCE IN BLACKPOOL

Reports of Technical Sessions

(*Continued from page 150, May, 1956*)

Abstract No. 8:

The General and Chemical Engineering Aspects of Electroplating Plant.

By H. C. Clements, B.Sc.(Eng.)

IN this paper the author deals with the services required in an electroplating plant and examines them in relation to efficiency, and finds that there must be a close link between the chemical, mechanical and electrical aspects.

Where the work is manually transported from one operation to another it is necessary to have floors that are acid resisting with gullies built into them. These gullies should not be placed under process tanks because of the corrosive effects which can develop when different effluents mix.

Most process tanks are fabricated from mild steel with appropriate inner linings to prevent attack by the solution on the steel. This method is not altogether satisfactory and an improvement on it is the use of fibre-glass and other resin-bonded materials. However they must not be used for a swill following an alkaline cleaner. At present no single material is suitable for all chemical and temperature conditions.

Electroplating solutions must be kept within narrow temperature limits and heat exchangers have proved successful. They have given a more even distribution of heat, and the return temperature of the solution has been no more than 50°F. above the actual operating temperature. The usual design of the heating service will heat tanks of 300 gallons from cold to working temperature in two hours.

All tanks operating at temperatures above 140°F. should have air extraction as well as those from which fumes arise. The call for fuel economy, etc., has resulted in the adoption of a system of lip extraction alternative to the double-suction slot method. The air is blown across the top of the tank from one side and extracted from the other. Slots are proportioned so that more air is extracted from the suction side than of air blown, which ensures a tendency for a down-draught to be produced.

Attention is now being given to fumes discharged to the atmosphere and the normal practice is to fit washing towers into the system, with an appropriate pump to maintain a curtain of water through which the air must pass before being discharged to the atmosphere. The overflow must be connected into the effluent treatment system for neutralization.

Swilling is an important service and optimum conditions can be maintained by a high rate of change of swill water. By fitting the intake pipes with anti-syphon injectors the condition is improved by agitation set up as air is taken in.

Two rinses are preferable and the second rinse has the overflow connected back to the supply of the first rinse, thus economizing in the use of water.

Provision must be made for the continual removal of harmful agents or deposits will lack ductility and brightness. Non-ferrous metals are best removed by low-current-density electrolytic treatment. The contaminating metals will be deposited as a grey-to-black deposit on the cathode plates. Ferrous contamination is best treated by chemical methods, and organic impurities are removed by activated carbon treatment. In the author's opinion the enclosed type of plate filter with a combined plate and frame is the most satisfactory, because it can be used for activated carbon treatment and also for ensuring complete dissolution of salts when making additions to the solutions.

* * *

Abstract No. 9:

Automatic Plant for Bright Zinc Plating.

By J. Chadwick, Assoc.M.C.T., A.I.M., A.R.I.C.

THIS paper describes an automatic plant to produce a protective deposit, on steel motor-car parts, which would not easily finger mark. The design of this first automatic plant for bright zinc plating was based largely on a dull zinc plant which had been in existence for some years. A double-line return type automatic was favoured which had a plating capacity of 288 sq. ft. per hour and a weekly output of over 250,000 components. The surface area of the components varied

from 2 in. square to 1 ft. square with a minimum deposit thickness of 0.0003 in most cases.

The majority of the components are given a preliminary degreasing in trichlorethylene and for heavy-duty cleaning in a silicate-type hot electrolytic alkaline degreaser with an addition of sodium hydroxide. The cleaner is renewed weekly and an addition made in mid-week.

Cold, 30 per cent by volume sulphuric acid is used to remove light rust and scale from the components and the tank is constructed of steel with a lead lining.

A solution of 60 per cent by volume sulphuric acid is used for anodic etching in a solid lead tank, and the temperature is kept below 80°F.

The cyanide rinse contains 4 oz. per gallon sodium cyanide and 1 oz. per gallon sodium hydroxide in a steel tank with a semi-hard bonded rubber lining.

The zinc content of the plating solution is maintained between 8 and 9 oz. per gallon with a metal : sodium cyanide : sodium hydroxide ratio of 1 : 3 : 2. Regular additions of organic brightener and sodium sulphide are made. With an average current density of 70 amp. per sq. ft. a deposit of 0.0006 in. is obtained in ten-minute's plating time. 99.99 per cent minimum zinc anodes are used and the tank is of steel with a semi-hard bonded rubber lining. Thirty six oval zinc anodes are placed opposite the centre of the stationary plating racks to give the most even distribution of deposit. There is a slightly lower deposit thickness on the side facing the centre anodes probably due to the fact that the centre anodes provide metal for both lines of racks and wear more rapidly than the outer ones.

The components are generally suspended on hooks except where they lack suitable holes or have recesses likely to trap air.

On leaving the plating solution the deposit has a greenish film which is removed by immersion in a 0.06 per cent nitric acid solution. After brightening the components are immersed in a dilute proprietary chromate solution which gives a slight passivation and increases the resistance to finger marking. Both these solutions are in stainless-steel tanks fitted with stainless-steel agitation pipes. The two solutions are renewed daily. A modified chromate solution has been obtained which gives a decreased metal loss and will withstand the time of 22 seconds between passivation and swilling without producing a streaky deposit.

Unheated running-water swills are used after each operation except alkaline degreasing where the water is heated, the 30 per cent sulphuric-acid dip and the cyanide rinse where swilling is omitted and the components pass on directly to the next operation. All the swills are fitted with agitation pipes generally made of the same material as the tank. The water for all the swills enters along the bottom of the tank.

It is possible to calculate the flow of swill water required but the formula only applies to well-agitated swills. The total water usage for all swills is approximately 3,000 gallons per hour and wherever possible clean water from other processes is utilized as well as well water which is the main source of supply.

Where space permits water consumption may be reduced by using two small swills between operations instead of one large one. This will also give a more efficient washing.

All the tanks are fitted with wooden covers round the edges which improves the initial appearance but the resistance of wood to sulphuric-acid solutions and hot alkali is far from satisfactory and the appearance soon deteriorates. A plastic sheet covering would probably be better.

Lip extraction is used for exhausting many of the tanks and no trouble due to fume is experienced providing the extractors are cleaned out regularly.

High-pressure hot water is used for heating purposes. The surface area of heating coil required is calculated from the volume of solution, or swill water, to be heated and the increase in temperature required. For maximum efficiency the distance between the coils should be at least twice the coil diameter.

The tanks are usually unlagged because it is felt that the cost of lagging and upkeep largely nullifies any saving in the cost of heating.

The current required by the various processes is supplied entirely from rectifiers. It is considered that the higher initial cost compared with that of motor generators is more than compensated for by the greatly reduced maintainance costs.

Discussion

Mr. A. W. WALLBANK (Ionic Plating Co. Ltd., Birmingham) asked why Mr. Chadwick wished to change his nitric acid-chromate method to a passivating bleach. Was it only for brightness?

One point in favour of automatic plants was that it was not necessary to have such an extensive drainage system, so many gullies and protected floor areas. He was in favour of heat exchangers, and mentioned one difficulty with heating coils immersed in the solution, namely the formation of solids. Mr. Wallbank thought that for most users the main difficulty about coils in the solution was their complete unreliability. If it proved possible in the near future to get reliable heat exchangers in this country external to the vats, they would all be very glad to have them.

Mr. Clements had mentioned the great diffi-

culty arising from air-exhausted plating plant of replacing the air sucked out with warm air. Mr. Wallbank was not sure that the push-pull method alone would help very much; the greatest hope was for some extension of scrubbers or some extension of the addition agents which some of them now put in their chromium solution, so as to get permission to recirculate at least some of the air that they were drawing away from their plants.

Dealing with plant in general, he had nothing but admiration for the engineering ingenuity of the large automatic plants, whether plating or polishing plants, but he thought that some of the everyday equipment which they had to use had been grossly neglected, and he was surprised that the smaller supply houses had not really tried to specialize on some of the more everyday items, the " intimate details " of plating, as Mr. Clements called them.

Taking some of the items of plant in turn, Mr. Wallbank referred first to the rectifier. The rectifier, he said, was one of the most trouble-free items of British plating plant, but it was rarely possible to run a rectifier at its rated amperage and voltage for long. He felt that rectifiers should carry different ratings for continuous and for intermittent use. Also he was not sure that the common method of using thermal fuse overloads was a good one; he thought that an electromagnetic method would be safer.

With regard to vats, most of those were just five-sided steel boxes, instead of pieces of chemical engineering equipment. It should not be unreasonable to ask the manufacturer to provide a sloping bottom to the vat, a sump with definite inlets and feed channels, radiused at corners for easy cleaning.

Mr. Wallbank agreed with Mr. Clements that the painting and protection of the outside of the tanks were important. Tanks often failed from the outside rather than from the inside. This could easily be improved if more care was taken in preparing the outside surface and it was coated with a good rubber-base protective paint.

If there was one field in which this country was behind the rest of the western world it was undoubtedly in plastic linings. It was possible to get tanks which would last, but it was unusual if they did and normal if they did not; and the larger the tank the greater the liability to failure. In the U.S.A., France, Germany, Holland and many other countries there were plastic tanks in use which apparently gave no trouble, but users in this country were badly served by their plastic linings.

With regard to heating, he would be very glad to hear where it was possible to get in this country some simple tubular metal heat exchangers, such as were common elsewhere; for example a tantalum heat exchanger for chromium.

Pumps on the whole were good, but it was the gland packings which caused trouble. With filters the position was improving, but the overall set-up of pump and filter was still largely unsatisfactory in this country. It was not planned as a chemical engineering unit with its own mixing tanks, bypass valves and so on as a neat piece of equipment.

Coming to polishing machines, proper polishing depended on correct peripheral speeds, but at present they had to have synchronous motors at one of two definite speeds or a clumsy belt change. A polishing motor which could be adjusted in speed properly, and at a reasonable price would be welcome.

As for barrels, the design had not greatly changed with the years. They still had walls about ¼ in. thick and tiny perforations which made it very difficult for the solution to change inside the barrel and for the current to reach the parts. It was revealing to take a sample of the solution out of the inside of a plating barrel when it had been running for half an hour. If it was necessary to have thick walls to give the required strength, at least let there be vanes on the outside of the barrel that pushed the solution in, or dispense with the use of a lid altogether.

He wanted to make a plea for more attention to be given to the simple, everyday features of British plating plant, and for some attempt to bring them up to the standard of excellence which the large and spectacular automatic plants had reached.

Mr. E. A. OLLARD (Atlas Plating Works, Ltd., London) said that a good deal of trouble came from the lining of the tanks, and he thought that the principal trouble was the accelerators in the rubber. Some rubber had been developed with accelerators that were innocuous to nickel solutions and he hoped that when tanks were supplied the necessary precautions would be taken to see that the rubber which lined the tanks did not include anything known to be harmful.

With regard to fume exhaust, when fume was coming from the surface of the plating solution in a tank it could be exhausted there, but in many operations when a basket of articles was removed it was still fuming, and arrangements had to be made to deal with that. That was sometimes neglected, and he had seen it neglected on at least one automatic plant, where there was trouble because the suction did not

cover the area in which the fumes were being produced. It was necessary to remember where the fume was coming from when trying to exhaust it.

The question of addition agents and additions to tanks generally was, he thought, more important than was often realized. Many people would have had the experience of analysing a tank and putting in the make-up only to find two or three hours later that it had ceased to function. This difficulty could be met by devising a type of feed which would enable make-up chemicals to be fed in steadily all the time, especially in the case of large tanks.

Reference had been made to pumps, and Mr. Ollard wondered why pumps had to have glands at all. In most cases a positive suction was not required on a pump in a plating shop, where it could be fed by gravity.

Another point about which he felt very strongly was spares.

It ought to be possible to have a proper service of spares, and it was ridiculous that spare parts should not be obtainable readily for most of the plating equipment in use in the industry even though the design of much of it had been altered.

Mr. E. J. BLEWETT (Wilmot-Breeden Ltd., Birmingham) said that Mr. Clements had referred to effluent and ventilation as being of secondary importance, but they would play a very important part in any installation of automatic plant. Following a polishing operation provision must be made whereby the removal of contamination was easily accomplished in the automatic cleaning line.

Tanks should be designed to assist ease of maintenance and overhaul. Mr. Blewett was interested in the suggestion that a universal plastic lining for tanks was possible and hoped it would be introduced. For chromium plating Mr. Clements said that the Americans used immersion heating coils. It would be interesting to learn something of their contruction and of the type of material used. Mr. Clements suggested an investigation into the various methods of solution heating to compare their effectiveness and cost. There were other factors to be considered besides thermal efficiency. Carbon-type heat exchangers were quite efficient, and their ease of installation and replacement, coupled with the fact that they did not take up tank space, meant that they had much to commend them. A pump, however, was essential to circulate the solution. Such heat exchangers had been used in the chemical industry for many years.

With regard to air extraction, the suggestion that extraction should be used with tanks operating above 140°F. was a wise one. This would prevent serious corrosion of equipment. The cost of water was becoming a serious charge on the plating process, and the consumption of water should be kept down. To get effective water rinsing, the rinse tanks should always have a higher level than the corresponding alkali and acid dips, a point which was often missed.

With regard to air agitation, he felt that other methods to give adequate mixing or effective stirring should be investigated, in addition to air agitation. Mr. Clements had suggested, for the maintenance of solutions, the addition of brightening agents on an ampère-hour basis. It was to be hoped, however, that methods of analysis for organic additions were not too far distant.

Mr. H. J. BACHE (Electro-Chemical Engineering Co. Ltd., Weybridge) said on the subject of chromium plating tanks and their linings, that he knew that lead or antimonial lead was still frequently used. Although plastic linings were available, there were some disadvantages in their use. It appeared that lead was not as insoluble in chromium solutions as at one time it had been believed to be. It seemed to be more soluble in the more concentrated solutions, and especially at elevated temperatures. That meant, of course, that the corrosion of lead coils could proceed much more easily in these more concentrated chromium solutions. One difficulty connected with plastic linings seemed to be that it was not possible to use them when the chromium tank was surrounded by a water jacket, since there was a danger of blistering of the lining occurring due to the high thermal gradient.

The amount of water which had to be used in connexion with the rinses and so on in an automatic plant always seemed to be a source of surprise to the customer when the quantity of water which he was going to use was pointed out to him. For a small automatic plant it was generally of the order of 1,500-2,000 gal. per hr.

With regard to plant maintenance and purification of solutions, he thought that the approach of users in this country was very different from that in America. Some years ago he had seen a fully-automatic plant of the return type in America which as a matter of routine was completely emptied and purified after every 100 hour of operation. That was not necessarily because of deficiencies in the plating solutions; it was regarded as an essential part of the routine by the manufacturing company which operated the plant. The wisdom of adopting that approach towards maintenance was brought out by the fact that although the output of that company

was extremely high their total reject figures from all causes was under 0.25 per cent.

He had a great deal of sympathy with Mr. Wallbank's long and depressing catalogue of plant deficiencies. He did not intend to refer to the items one by one, but in general he would like to say that there was a great tendency on the part of people who bought plant, when they received quotations from rival companies, to judge solely on the basis of the price quoted instead of comparing what would be obtained for the different prices charged. It was possible, of course, to have specially designed tanks. If the supply house was willing to provide these tanks or other specially designed equipment, the decision rested with the customer, who had to decide whether he could afford to pay for the novelty of the design.

In connexion with the ventilation of plant, with particular reference to chromium plating, there was now a much neater way of dealing with the spray from chromium-plating solutions than had been available before. If use were made of one of the new spray suppressors, it would be possible to use a much smaller unit for extracting the spray from the chromium-plating solution. Mr. Ollard had referred to adding addition compounds to plating solutions. Mr. Bache knew of a number of instances where a drip feed system was now being used quite successfully.

He would like to end on a more optimistic note by pointing out some of the advantages to be gained from the use of automatic plant. An automatic plant was really a high-capacity production unit, and as such it should be welcomed by plant economists and planning engineers. To give an example, a small automatic plant dealing with relatively small components such as cycle-wheel hubs, hub nuts and things of that kind could turn out in a normal working day about 30,000 components. At the other end of the scale, with quite large articles such as window frames measuring, say, 10 ft. × 6 ft., the plant might have a capacity approaching 30 tons per day. That made the automatic plant a really attractive proposition for handling large components. When large or heavy components were being dealt with it was possible to load them on to the plant by automatic means. Automatic rack loading equipment was available which would put the work on and take it off after it had been given the treatment for which the plant had been designed.

Finally, there was the idea, which he thought was becoming more prevalent, of using automatic plant in jobbing plating shops. At one time the view had been taken that this could not be done, but it was an idea which was becoming more attractive, and it was now quite feasible for jobbing plating shops to make use of automatic plating equipment. Frame type racks could frequently be used which enabled many diverse types of article to be attached to them. So far as the future was concerned, he thought that the use of automatic plant in jobbing shops had much to commend it.

Mr. U. F. MARX (Wilmot-Breeden Laboratories, Solihull), referring to the paper by Mr. Clements, suggested that in the foreseeable future the problem of effluent, particularly in relation to local authorities, would become more serious, and probably the regulations regarding the discharge of effluent would be made much more stringent. It would be interesting to know whether the supply houses had given any consideration to the possibility of putting in continuous treatment plant which would treat the swill water as well as any solutions which might be thrown down the drain. He would like to have their views on that problem, because it was likely to arise in a very acute form in the future.

On the question of materials of construction, the new solutions required more and more filtration, so that the problem of filter materials was becoming quite important. A short time ago he had seen a brief and uninformative notice from the Continent about the marketing of a p.t.f.e. material, and he would like some further details about that material and its suitability for use in filters and for anode bags.

A point which had not been mentioned at all so far was the use of new methods of agitation in cleaning. He had in mind in particular ultrasonics. He believed that some progress had been made in that direction, but would like to know more about it.

Mr. D. E. WEIMER (M. L. Alkan, Ltd., Greenford) thanked Mr. Clements for drawing attention to the many factors which governed the economic operation of plating plants, and particularly those of the fully-automatic type. The paper gave clear warning to the smaller jobbing platers who might be contemplating automatic equipment for some of the more complicated plating processes that the plating machine was not the only item involved.

Barrel plating equipment had been referred to by two other speakers. In recent years a new type of barrel had been introduced, namely the open slot cylindrical barrel. This incorporated a shelf which retained the work when the barrel was rotating in one direction during plating and when it was required to empty the barrel, the rotation was reversed and the work fell out of the slot into a container, which was withdrawn.

It was possible by that means to unload and load the barrel with 30-40 lb. of work in 20-30 sec. That type of plant had been developed for even larger quantities of work, and it was now possible to handle as much as 90 lb. of work virtually manually, without the need of block-and-tackle equipment.

Mr. Ollard had raised the question of spares, but he would like to make a point concerning the routine servicing of plating equipment, particularly barrels. When using this type of equipment, users should ensure that it was regularly serviced. That did not take long, and it would ensure a longer life and obviate the necessity of having to buy spares.

Author's Replies

Mr. H. C. CLEMENTS said that everyone was worried about tank linings, both suppliers and users, and much research was being carried out on the subject. They all hoped that in the course of time something would be found which could be used for all solutions. Mr. Wallbank had referred to tantalum. This metal was in very short supply and was exceedingly costly and could not be considered a practical proposition.

With regard to fume extraction problems, there was an equipment which really consumed its own fumes. He did not suggest that such an installation would become a commonplace; it could be very troublesome and difficult to maintain.

Steps had been taken to deal with the recirculation of air in plating plants, and it had been found possible in the case of a plant using 50,000-60,000 cu. ft. of air per min. to reduce that figure to such an extent that approximately 20 per cent of the air was blown out; in other words, only 20 per cent of the air had to be heated to bring it up to the shop temperature.

So far as agitation was concerned, he agreed with the possibility of air being replaced by some other method. Work was being done on the agitation of plating solutions, particularly where large components were concerned, and success had been achieved with paddles and circulating systems fitted on the outside of the tanks. Considerable developments were likely in the next three or four years.

With regard to lead linings, they were trying out the possibilities of cathodic protection not only of linings but of general fittings such as filter pumps. It was too early as yet to know whether cathodic protection would be the solution to the difficulty. It was extremely difficult in the design of plant to stop circulating currents through external circulating systems, and rather than go to the considerable expense involved they were looking for some other means of protection which would overcome the problem of corrosion, which in some instances was very serious indeed.

Quite a number of firms, apart from the suppliers of plating plant, were dealing with the problem of effluents. While appreciating that in time it would probably be part and parcel of plating plants, at the present time the cost of effluent plant was so considerable that there was resistance to spending the money on it when it was hoped that in two or three years' time some easier method would be available not only of treating the effluent to meet the conditions imposed by local authorities but also to get it back into the plant.

Mr. J. CHADWICK said in reply to Mr. Wallbank that the reason why they had considered changing to a chromate passivation was that corrosion tests had shown that this gave superior protection to the nitric acid dip. The main reason for wishing to change, however, was that if the steel parts were rough and dull, which happened with 2-3 per cent of the components, the nitric acid brightening was insufficient and only a semi-bright finish was obtained.

With regard to barrels, he wondered whether anyone had tried a steel barrel with a thin plastic covering, and whether it would be possible to fit a solution feed to circulate the solution into the centre of the barrel and so outwards to the plating tank itself.

Mr. Ollard had mentioned drip feed. They were trying this out at the moment, because they felt that it was very desirable. Mr. Blewett had mentioned carbon heat exchangers. The only experience which Mr. Chadwick had had when trying this out was that within two hours the carbon heat exchanger split into two pieces, and that had been the end of it so far as they were concerned.

Abstract No. 10:

Laboratory Evaluation of Paint Durability—Accelerated Weathering Tests.

By T. R. Bullett, B.Sc., A.Inst.P.

A PAINT film, from the time of its application onwards, is never in a condition of completely stable equilibrium but is continually changing both in chemical structure and in physical properties. This paper discusses the potentialities and shortcomings of accelerated laboratory tests of paints which in normal use are subjected to outdoor weathering exposure.

It discusses the structure of paint films and divides them into two main types, *viz.*: those in

which the binding medium is a solution of polymeric material capable of conversion into a solid film merely by loss of solvent, and those of which the medium consists of lower molecular weight material which undergoes chemical conversion before a solid film is formed.

The mechanical properties of solution-type coatings are determined by the flexibility of the polymer chains and the nature of the forces between the chains. Changes in these properties are usually associated with oxidation. The chemical conversion type are more complex and depend on the formation and subsequent decomposition of hydroperoxides attached to the unsaturated fatty-acid chains leading to the development of cross links between chains. These reactions can occur by a number of routes and result in many end products.

The changes which occur in oil-varnish and alkyd-resin based paints are less drastic than those in oil paints. In varnish the film formed is generally less reactive than an oil film but is still subject to the same type of breakdown reactions.

Since the field is so wide this paper is concerned mainly with attempts to assess the durability of paints which are normally exposed to natural weatherings on buildings, bridges, etc.

The chief factors promoting paint breakdown due to natural exposure are given, namely: temperature, light, including ultra-violet radiation, and water. There are also purely chemical factors: oxygen, ozone, the constituents of atmospheric pollution, sulphur dioxide and chlorine and acids and alkalis which may be either airborne or derived from the substrate. These are the main causes of the chemical and physical ageing of paint films.

The laboratory exposure test should be regarded as an accelerated ageing treatment rather than a weathering test and this means that it should produce chemical and physical changes which occur during natural exposure.

Facts that are available indicate that paint films are most rapidly aged in the late spring and summer, due to excesses in sun, rain and temperature.

The factors used in the test to approximate to these weather conditions are an artificial light source for ultra-violet radiations and water sprays at a slightly higher temperature than that of dew or rain. The test conditions must not be more severe than the worst natural ones. A safe limit is between ten and twenty times normal.

The results of weathering tests are given but it is pointed out that weathering is not an exact science and that the conclusions reached are a matter of opinion rather than of fact.

With oil and oil-varnish paints the results were good and the colour and gloss changes correlate with those which occur outside; embrittlement of films also follows the same general pattern. However, it does not always produce the visible film failure which would occur with natural exposure. It is less satisfactory with multicoat systems because the types of intercoat adhesion failure are rarely reproduced.

The results obtained with other paints are less comprehensive and it is difficult to reach clear conclusions. Nitrocellulose lacquers in general follow the accepted pattern, but bituminous paints, other solution-type lacquers, and cold catalyzed resin films do not respond very well.

It is perhaps best to consider accelerated weathering mainly as a test of stability of the film structure. The most profitable future field of development in durability testing would appear to be the combination of accelerated weathering as an ageing treatment with mechanical testing to assess structural changes.

Discussion

Mr. R. J. BROWN (British Motor Corporation, Birmingham) said that the Paint Research Station were more interested in household paints and in structural paints for civil engineering, whereas the motor industry were concerned with very specialized forms of paint which gave an exceedingly high finish, and which at the same time had to have exceptionally long life. He therefore, looked at the subject of accelerated weathering from a somewhat different angle from that of the Paint Research Station.

He supported the author's contention that climatic conditions varied even within one country. The motor industry were not concerned with exposure of painted products in Great Britain alone, but everywhere, from sub-arctic to tropical areas, and when various parts of the world were compared the fluctuations were wider still.

The breakdown of paint was largely due to three factors. High humidities associated with high temperatures and wide temperature fluctuations. The temperature fluctuations led to condensation, often more destructive than precipitation as in rainfall. The second factor was high temperatures resulting from the infra-red of solar radiation, and the third, ultra-violet radiation from solar radiation.

He could not agree with the author that accelerated weathering should be regarded as the treatment of the film. The author dissociated the system of covering and divided it into individual films, carried out accelerated weathering treatment and assessed the properties of the individual films. Unfortunately, they did not use films of paint as such; they were keyed to a base material, and also to other coatings. It was the interaction

of those coatings which often led to failures in service. From a fundamental aspect the study of individual films was necessary, but for accelerated weathering it was necessary to consider that there was a place for accelerated weathering as a treatment and for accelerated weathering as testing.

In their own researches, the sources of ultra-violet light had been considered on the basis that in the past the carbon arc had been largely used. Comparing the percentages of the wave-lengths available, the closest comparison was between the carbon arc and sunlight, but the intensity at the higher frequencies and lower wave-lengths was one of the factors which brought about acceleration of breakdown, and for that reason they had selected the high-pressure mercury arc as being the most suitable means of accelerating breakdown.

When they started their work they had not much experience apart from complaints from the field, and so they set about having panels exposed in various parts of the world to assess the value of their test procedure. As a result of that, a prototype unit had been built, and since then the designs had been put into production. The unit was based on a vertical water-cooled mercury arc to provide the ultra-violet radiation, a battery of infra-red lamps to provide the heat cycle, and a water spray operating on a precise cycle, with a control cabinet.

Samples exposed at Durban at different times of the year showed quite a difference in appearance; in the first period there had been pronounced crazing, and in the second there had been chalking and pitting which would subsequently develop into crazing. Other samples had been exposed in Salisbury, in the same country, but a different location, Durban having high humidity and Salisbury low humidity but high temperatures, and also at Singapore, with high humidities and high temperatures. There were some similarities between breakdown at Durban and at Singapore, but the breakdown at Singapore was more severe.

As a result of these tests an accelerated weathering cycle had been developed. Obviously the cycle could be so arranged as to develop gross crazing, but the aim had been to develop an average sort of breakdown. Mr. Brown said he believed that the Paint Research Station based their tests largely on exposure tests at Teddington, which was one location. Possibly they were more interested in the performance of paint films in Great Britain, but the motor industry had to take account of the whole world and thus adopt a different approach.

He had evidence that an accelerated test could produce the form of breakdown which was obtained in the field, which was rather contrary to the author's statement. Paint technologists should aim at some form of test applicable not to an individual paint film but to a paint system. The performance of paint coating depended not only on the properties of the individual films, but on their inter-relationship, and also on the method of application.

Mr. T. R. BULLETT, replying said that on the question of light sources, he was still not happy about the use of high-pressure mercury arcs for this work. In some cases it would be satisfactory, if there was a fairly broad absorption, but with polymers which had specific absorptions at different wave-lengths it was possible to get very different results with sources which contained a good deal of shortwave ultra-violet intensity which was almost entirely missing from natural sunlight. That was why they had continued to use the carbon arc, first of all on the basis of colour fastness tests, where they found that mercury arcs were very dangerous and did not give at all a good correlation on many dyestuffs. They had carried that over to the weathering field. He had read one or two American papers which showed that when considering weathering in plastics it was possible to go badly astray when the high-pressure mercury arc was used.

Mr. Brown was not quite accurate in deducing that they based their work on exposure tests at Teddington only. They maintained exposure sites at several places in this country, and during the period when most of their development work had been done on accelerated weathering, they had had a site in North Devon, one on the Solent and one in Manchester, in addition to that at Teddington. They had not, however, attempted to correlate with exposures in other countries. That was a very practical problem. As Mr. Brown had shown, the performance varied so much from one place to another that it was difficult to see how it would be possible to get an accelerated weathering test which correlated on all of them.

On the question of testing either individual films or systems, he agreed that it was desirable to test systems, because the inter-relation of the various coats was very important. On the types of paint system with which the Paint Research Station had been concerned, they had had very little success in tests on systems. They had never succeeded in reproducing the most prevalent types of failure, involving flaking between coats and so on, which were obtainable outside, when using their type of accelerated weathering system. He was not clear whether Mr. Brown had repro-

duced that kind of thing or not; the examples he had quoted were of the crazing and chalking types which were usually obtained on a single coat as well as on a system.

Abstract No. 11:

Polytetrafluoroethylene Dispersions for Metal Finishing.

By E. M. Elliott.

THE properties of polytetrafluoroethylene are discussed in this paper and in particular the increased scope of work for which it may be used. These properties include a working temperature range of —100 to +250°C., extreme chemical inertness and resistance to chemical attack, first class electrical properties, good mechanical properties, a low co-efficient of friction and anti-adhesive properties.

The first patents claim a process for production of aqueous dispersions of p.t.f.e. by polymerizing tetrafluoroethylene in contact with an aqueous solution of a saturated aliphatic dibasic acid peroxy compound while agitating the solution. By using such catalysts in stainless-steel autoclaves relatively stable dispersions of p.t.f.e. with solid contents of 5 to 10 per cent by weight may be prepared. The dispersion is then stabilized and concentrated by means of electro decantation.

The dispersion is irreversibly coagulated by the addition of electrolytes, many miscible solvents, freezing, boiling or mechanical agitation. To make the dispersions more stable against coagulation small amounts of anionic or non-ionic surface active agents are added. Stabilized dispersions have an indefinite shelf life if they are kept at about 5°C. and occasionally stirred.

The dispersing agents stabilize the dispersion and also impart the necessary wetting characteristics to ensure uniform spreading over such surfaces as metals, glass and ceramics.

Modified dispersions can be obtained by the addition of chromic and phosphoric acid, from 10 to 25 per cent by weight, which will give priming coats of sufficient thickness in one application. The dry film is only 0.0003 to 0.0006 in. thick. There is a second type of modified dispersion which has been developed for application on top of the "primer" which contains in addition to p.t.f.e. an emulsified organic liquid such as toluene. This wets the primer and enables the application of extra coats to build up the required thickness. The critical thickness for one application is 0.001 to 0.0012 in. and the total maximum thickness is about 0.005 in.

The surfaces to which p.t.f.e. dispersions are to be applied must be carefully prepared and must show bright clean metal. The work to be treated should first be heated to 420 to 430°C. for a time slightly longer than that which will be required for baking the p.t.f.e. dispersions. This is to decompose and drive from the pores of the metal any foreign matter which might otherwise be forced out during sintering and cause blistering and bad adhesion of the dispersion. Care should be taken that there are no deep scratches on the surfaces or the dispersion flows into them and becomes too thick to sinter without the formation of "mud cracks." Dry cleaning with steel wool or fine emery paper is effective because it leaves an ideal matt surface.

Dispersions may be brushed, dipped or sprayed on. Dip coating is preferable on continuous sheet or strip, while spray coating is satisfactory for most general applications.

After applying the priming dispersion it should be allowed to dry for 10 minutes at room temperature and then placed in an oven and heated to 90°C. to drive off all the water and then while still at the same temperature transferred to an oven heated to 400°C. When it has cooled to room temperature a coating of the coloured finish is applied to give a thickness of 0.001 in. dry film and the same process repeated. Subsequent coats may be applied to give a maximum thickness of 0.005 in. Above this thickness there is a serious danger of "mud cracks" developing.

If the work is quenched in water after the final baking the film will be tougher and more transparent than a slow cooled one, but it cannot be applied to glass, ceramics, copper alloys or work which will distort through a rapid change in temperature.

With primer dispersions which give a 0.0003 in. thick dry film basis, approximately 500 sq. ft. can be treated by 1 gallon.

Traces of vapour are given off when p.t.f.e. is processed at high temperatures and so adequate ventilation must be provided. Also as the dispersions are acidic face masks and goggles must be worn to prevent the spray being inhaled or getting in to the eyes.

The most popular applications appear to be for anti-adhesive purposes especially on baking and confectionery machinery, textile plant, automatic weighing and packing machines, conveyors, heat sealing machines and printing equipment.

Discussion

Mr. H. SILMAN (Electro-Chemical Engineering Co., Ltd., Birmingham) said that at a discussion at an earlier session on chemical engineering problems in connexion with the construction of electroplating plant, it had been stated that the people who produced electroplating plant which was designed to prevent corrosion in the products going through it often did

not pay sufficient attention to the protection of the plant itself, so that more often than not the products outlasted the plant. There was accordingly every incentive to utilize materials which would not be subject to corrosion. Until very recently there had not been a single thermoplastic material which would stand up to anything approaching the boiling point of water, but now there was p.t.f.e., which was a thermoplastic of sorts, which could go to a much higher temperature range than that employed in electroplating applications. More recently there had been a new form of polythene which would go up to about 110°C. Some attention ought to be paid to the possibilities of these products.

P.T.F.E., owing to its high cost, was quite impracticable as a material for use in the massive form, and its application as a thin film was therefore viewed with considerable interest. In some respects p.t.f.e. films were rather like nickel coatings. Nickel coatings as such were inherently non-corrodible, but the film, being porous, allowed attack to go on through it, with the result that corrosion of the base metal occurred. The same thing seemed to happen with p.t.f.e. films, and the sponsors and users of the product were faced with finding a technique of making films of p.t.f.e. relatively non-porous. He wondered whether any thought had been given to the possibility of rolling or the application of pressure to the film to eliminate the porosity, and whether such treatment would make the material more durable.

It was very fortunate for the industries in which they were interested that the company making p.t.f.e. were themselves one of the largest chemical engineering firms in the country, and should have ample opportunities for testing it out themselves. They must have very similar problems to those in which members of the Institute were interested, and he would like to know whether they had any practical experience of the use of these films under severe conditions.

Mr. Silman's company had had experience of the use of p.v.c. linings on metals, and in those cases, though the p.v.c. itself was fairly good, trouble occurred when an attempt was made to apply it as a lining or coating, because under conditions of expansion and contraction, with relatively difficult materials to bond such as p.v.c., loosening of linings occurred, and, in spite of the different techniques which had been adopted, the results had never been entirely satisfactory. Since p.t.f.e. had even poorer adhesive properties than p.v.c., it would be interesting if the author would say whether the bond with p.t.f.e., applied by the techniques which he had described, tended to become weak and to loosen under repeated heating and cooling in service conditions.

The non-sticking and high lubricating characteristics of p.t.f.e. offered some interesting possibilities. In electroplating plant in particular, conveyor chains had always caused a great deal of trouble, and quite a number of manufacturers of such plants have now gone away from the use of conveyor chains entirely for that reason. The chief difficulty was the problem of lubrication, and when the chains were lubricated with greases and conventional lubricating materials these products tended to get into the plating bath and cause endless trouble, and there were other difficulties. Nevertheless, if it were possible to use a chain with low frictional characteristics by the application of p.t.f.e., without the need for periodic lubrication, it would open up a new field in which conveyor chains might be useful once more. The possibilities of barrel linings in p.t.f.e. were also obvious, because of the low frictional characteristics and therefore high durability and high electrical properties.

There was one small point concerning the high electrical properties of p.t.f.e. coatings which should be mentioned. It might well be that, because of those characteristics at pores in the coatings, there would tend to be a very high concentration of electrolytic cell action, and therefore the rate of attack at pores might be increased much more than would be the case if the electrical characteristics were not quite so good.

Mr. T. R. BULLETT (Paint Research Station, Teddington) said that p.t.f.e. was a most interesting material, and it seemed to be quite easy to spread most types of paint on it, though a dry paint film showed very weak adhesion. That was useful in testing work, in that it was a very good method of preparing detached paint films with very little strain in them, and it had proved most valuable.

Mr. W. E. CATTLEY (The Walterisation Co., Ltd., Croydon) commenting on the author's statement that some cases of poor adhesion have been traced to phosphate or other metal cleaning treatments, and these therefore could not be recommended, said that he could not accept the reason which was given by the author that the surface deposit degraded at the temperature required to sinter the p.t.f.e. and so caused bad adhesion. There were many series of tests which had been done with phosphate coatings at high temperatures. Zinc phosphate lost water but would stand temperatures up to 450 or even 500°C., and iron and maganese had gone to 600 or even 650°C. in some conditions. It seemed to him, therefore, that they could not be the real

cause of any bad adhesion. He believed that there was a patent which used a phosphate treatment in conjunction with p.t.f.e. for the provision of a bearing surface, which seemed to indicate that phosphates could be used successfully with p.t.f.e.

Mr. Silman had referred to the use of p.t.f.e. for lubrication of conveyors. He understood that remarkably good results had been obtained using MoS_2 as a lubricant for conveyor chains. It gave very low friction, with little or no risk of contamination of the solution.

Dr. G. E. GARDAM (Aluminium Laboratories, Ltd., Banbury) asked whether there was any prospect of using the dispersions on sheet to facilitate drawing and to preserve the surface, which would greatly reduce polishing, and of using them to facilitate high temperature extrusion of, say, aluminium alloys.

Mr. N. GROSS (Wilmot-Breeden, Ltd., Birmingham) said that the sintering temperature for the material in question was given as 400°C., and the maximum working temperature as 250°C. He would like to ask what was the effect of a time of, say, 75 minutes at 400°C. undergone by the primer coat of a three-coat system. Did any reflow of the primer coat occur with the sintering of subsequent coats? Was good adhesion between the coats obtained? With conventional stoving enamels problems were occasionally met with.

When spreading aqueous dispersions on to cold objects to give film thickness of the order quoted, they had experienced severe sagging of the applied film. What was the objection to preheating the object to be coated before spraying to accelerate the evaporation of water to prevent this? It was stated that after sintering one coat the work was allowed to cool to room temperature before application of the finishing coat. Why was this necessary?

When using silicone release agents for moulds, it was difficult subsequently to obtain paint adhesion on them. Would this also be true for mouldings produced in p.t.f.e.-coated moulds? Could a higher gloss be obtained by this sintering technique? On the question of adhesion, what degree of polarity was exhibited by p.t.f.e.? Why was good adhesion obtained by this sintering technique on polar materials such as metals and glass, and yet no adherence to epoxy resins, animal glues and so on, which were polar? What was the theoretical explanation of the non-adhesive properties of p.t.f.e.?

He had seen an article in a U.S. journal where a method utilizing liquid sodium treatment was described for pre-treatment of metals so that good adhesion of p.t.f.e. in the solid form could be obtained.

Dr. E. E. LONGHURST (Armament Research and Development Establishment, Woolwich), on the subject of adhesion, said that the author referred to the practice of adding chromic acid and phosphoric acid to influence the adhesion, but at the same time advised against surface treatment as being likely to destroy the adhesion. There were water washes based on chromic and phosphoric for steel which were known to improve the resistance of any protective system based on a paint following these washes, and it seemed that that would be a more reliable practice than adding them to the resin direct. What was the effect of adding a good deal of electrolyte to these dispersions? When it was considered that the coating had finally sintered, what happened to the considerable amount of chromic and phosphoric acid which had already been put on the surface? It was needed only at the surface interface, and it seemed more reasonable to apply it as a thin film before adding the dispersions rather than to add it to the main bulk of the p.t.f.e. film and then use only that little bit which was up against the surface.

Mr. E. M. ELLIOTT, replying to the discussion, referred to the use of p.t.f.e. in plating equipment and said it was highly probable that its use in massive form was going to be the answer. The objection would be one of price, but if an indefinite life was going to be obtained, the first cost did not matter at all. He had known instances where the cost of using p.t.f.e. on certain packings had been in the region of one hundred times the cost of the material which had been used before, but with conventional materials the packings had had to be changed once a month, but with the p.t.f.e. packing it had been put in place and four years later, when the company decided to rebuild the plant, they took out the original packing which had been put in. First cost was not always the first consideration; it was necessary to take into account the length of life which could be expected. In addition, p.t.f.e. dispersions could be used for the impregnation of glass cloth and abestos cloth, and it was very possible that the use of either p.t.f.e. glass cloth laminate or p.t.f.e. asbestos laminate would be an answer to some of the poblems which occurred in plating equipment.

Mr. Silman had asked about rolling or pressure on the film. Mr. Elliott did not know of any work which was being done on that, and thought it might help to do some work in that sphere. What effect it would have on permeability was not clear, though if one veneered a film and heat-treated it and afterwards rolled it, certain pro-

perties could be improved considerably.

It was early days to say what use would be made of the material by his own company. Many of their divisions were trying p.t.f.e. in one form or another, but very little use so far had been made of dispersions, and the work up to now had been mainly concerned with the material in the massive form. P.T.F.E. bushes would probably be extremely useful for the bearing points in plating chains, because they could be run dry or alternatively they could be lubricated by the solution in the plating jig. There were cases where p.t.f.e. was used in pumps and so on, and the fluid being pumped was used as a coolant in the bearing.

Mr. Silman was probably quite correct in his comments about the electrical properties and the electrolytic cell action, but it might be possible to improve the results there by making the p.t.f.e. dispersions conducting. They had actually done that. They had a material with wonderful electrical insulation properties, but they had been asked whether they could make it conducting, and so eventually they produced a conducting dispersion. Mr. Elliott did not know whether that was an answer to Mr. Silman's question, but it was possible that it would be a useful thing to do.

It was encouraging to know that Mr. Bullett had found a useful application for p.t.f.e. and that he was able to get good paint films.

Mr. Cattley had raised the question of phosphates and cleaning the metal. Mr. Elliott was chiefly concerned with the use of plastics and was not fully familiar with the various metal finishing processes but so far experience had shown that where phosphates had been used they did not give the best results. He did not think that the reason for that was fully known, but it was possible that there might be some chemical action between the phosphates and the p.t.f.e. at sintering temperatures. MoS_2 could be added to p.t.f.e., and in fact that had been done on a number of occasions in order to obtain a bearing material. With regard to the use of dispersions for drawing metal and in high temperature extrusion of aluminium alloys, he thought that that was a difficult problem. While the p.t.f.e. could be made to adhere to the aluminium quite well, it had a fairly low abrasion resistance, and he felt that in deep drawing work the p.t.f.e. film would probably tend to tear. Presumably the temperature for extruding the aluminium alloy would be well above 400°C., and if that were so he was afraid that the p.t.f.e. would very rapidly decompose.

There had been other questions on the subject of adhesion. The theory and the mechanism of adhesion were not fully understood, but it was believed that the addition of the acidic materials etched the metal and so gave a mechanical key. If electrolytes were added to the dispersion, there was very serious danger that instead of having a mobile fluid which could be applied by spraying and painting and so on, the dispersions would coagulate and the material could not be used at all. With 75 minutes at 400°C. he would not expect much to happen to the dispersions, but if that treatment were carried on for a long time the p.t.f.e. would begin to depolymerize, and at just above 400°C. depolymerization took place fairly rapidly.

Abstract No. 12:

The Painting of Magnesium Alloy Surfaces and the Principle of Surface Sealing.

By W. F. Higgins, B.Sc., M.Sc., Ph.D., A.R.I.C.

THE painting of magnesium is no more difficult than that of many other metals provided that normal good painting practice is followed. Two features of the metal, *i.e.* its surface reactivity and the alkaline nature of the reaction product, have to be given attention, however, and the importance given to these two features depends to a great extent on the severity of the conditions to which the metal is exposed.

Magnesium tends to react with aqueous solutions generally and particularly with acid media, and the oxide film formed is not self-stifling as with most aluminium alloys. The reactivity of the metal is much increased by cathodic particles introduced by such processes as shot blasting; emery paper similarly leads to undue corrosion due to the embedding of particles in the metal surface.

To counteract such effects a method has been developed for cleaning magnesium-alloy surfaces by an anodizing process in a solution of ammonium bifluoride using alternating current at about 100 volts. This treatment gives a chemically clean surface coated with a very thin film of mixed magnesium fluoride and oxide which makes an excellent paint base.

The oxidized layer produced by reaction of the metal with the atmosphere is distinctly alkaline in nature, and thus best results are obtained with paint films which are more resistant to the transference of moisture.

Before painting it is usual to treat magnesium alloys with a chromating process, those approved by the Ministry of Supply being contained in D.T.D. 911A. The films formed by chromating must be strongly adherent and painting should be carried out as soon as possible after the chromate

film has been produced. The chromate treatment may also be carried out on material which has been anodized.

In order to reinforce the chromate in the chemically developed film it is usual to apply a coat of priming paint containing chromate. Although zinc chromate has been used for many years recent work has shown that other chromates, *e.g.* strontium chromate may have superior characteristics.

As regards etch primers, although as a class they have no special merit when used on magnesium, they are usually satisfactory in practice. Experimental work has suggested that the removal of moisture from the metal surface, *e.g.* by a low-temperature stoving, is more important than the "etching" effect.

With the use of a suitable primer the type of top coat is less important, provided it is durable and not too sensitive to alkaline conditions. In general stoving paints give better protection to magnesium than air-drying types, because in addition to being more resistant to the passage of moisture, the stoving process removes adsorbed moisture from the surface of the metal and leads to improved keying. Zinc-rich paints have no particular advantage when used on magnesium.

The practice of coating magnesium with lanolin as a temporary protective leads to subsequent difficulties in degreasing, which can only be carried out efficiently by vapour degreasing or by a boiling alkaline cleaner.

This problem is accentuated if the magnesium has been given a chromate treatment as the lanolin soaks into the film. The use of a light machine oil instead of lanolin is to be preferred.

It is essential that for painting the surface of the metal should be quite dry, and to this end warming of the metal is beneficial.

For really difficult environments, where condensation, etc. causes damage to the paint film, Araldite 985E, cured by stoving at a temperature of 200-220°C. can be used. This material should, however, not be applied on a cold damp surface, or blistering may result. The surface must also be chemically clean. Porosity and similar surface defects are overcome by filling the defects with resin (surface sealing). One of the virtues of the epoxy resins is that they pass through a very labile condition immediately prior to complete polymerization and in this condition they are readily absorbed by such porosity, provided that the pores are not already filled with moisture.

The practical solution, therefore, is to pre-stove the article which is to be surface sealed, to a temperature at least as high as that at which the final stoving will be effected, allow to cool somewhat and then apply the resin solution preferably by dipping.

The sealing procedure should be regarded as a foundation treatment not a finishing process where a paint finish would usually be given, although the treatment alone provides adequate protection in most circumstances. For outdoor exposure, a normal painting scheme should be applied on top. It should be noted however, that a priming paint is not required, although there is no objection to the application of a normal chromate-bearing primer *over* the surface of the resin layer, and this in fact should be done where maximum protection is required.

Discussion

Mr. R. L. YEATES (Docker Bros., Solihull) said that he welcomed the way in which the author underlined the necessity for the drastic cleaning of metals and he was particularly pleased with the author's reference to the necessity of coupling painting schemes with the conditions of service. The point which the author made about the alkaline nature of magnesium was very important in formulating a paint for that purpose. On the question of the use of a chromated primer, it was not stated how much chromate should be in the film. There were different views about that. A fully chromated primer was used on the magnesium alloy Ferguson tractor gearbox to which the author referred. The author also mentioned the use of etch or wash primers. That was a very wide subject. The reaction involved was a very complicated one and not just a simple formation of the magnesium phosphate. Current practice was to pass the metal through the chromate bath first, owing to the possibility of pinholing if the etch primer was used direct on magnesium.

The process of surface sealing which the author described was most interesting, but although no doubt a temperature of 200°C. was nothing to a metallurgist, it was rather high for general stoving conditions in industry. While he appreciated the value of the epoxy resins for special purposes, at the same time, in view of this question of temperature, he would like to ask whether the author had done any comparative tests with more orthodox stoving varnishes such as alkyd u.f. A paper by Cole and McKay, of the R.A.E., described a series of experiments with this alloy in which the epoxy resins were compared with other standard finishes. Their findings, after salt water exposure and temperature exposure, were that while the epoxy resins gave excellent performance, so did the normal standard stoving schemes and the standard air-drying scheme DTD.260.

Mr. C. WATTS (Wilmot-Breeden Laboratories, Solihull) said that it was to be expected

that if a protection scheme on magnesium was damaged the exposed area would corrode. In the case of a surface protected by sealing and paint, how did the corrosion of a scratched area proceed? Was there much spreading from the scratch, as with non-phosphated steel, and would this locally exposed part of a larger area corrode more heavily than with orthodox and more pervious schemes? He had in mind that the total corrosion which might otherwise occur over the whole surface might be concentrated at the local defect.

Mr. A. W. BRACE (Aluminium Laboratories Ltd.) asked for more details of the fluoride anodizing treatment which the author recommended What was the concentration of the fluoride in the solution, and the temperature? A point not adequately brought out in the paper was the real merit of fluoride anodizing as compared with chromate treatment. Was fluoride anodizing very much more effective in removing traces of surface contamination? What was the cost of fluoride anodizing compared with the other surface treatments with which many of them were familiar?

In connexion with priming paints, the author referred to zinc-chromate primers. Was he referring to basic zinc chromate or zinc tetraoxychromate, or other types? Did he feel that greater solubility and greater stability at different *p*H concentrations were to be preferred in such primers?

Many people would like to debate with the author the actual merits of the epoxy type of sealing treatment as compared with some of the others. It seemed to Mr. Brace that the epoxy treatment would probably give exceedingly good protection if the job was done 100 per cent, but in industry it was often impossible to get that with such a type of treatment, and with this impervious type of coating on the metal if there were one or two local breakdowns rather worse corrosion would occur than would take place with a more permeable system where the corrosion was much less localized and the chromate primer was much more capable of dealing with it. The author's observations on this matter would be welcome, because there was also the difficulty of the higher stoving temperature for the epoxy resins and there was the question of their general overall performance.

Dr. W. F. HIGGINS, in reply, said that Mr. Yeates had suggested that a temperature of 200°C. was too high. It was stated in the paper that this was a special treatment and not meant for the generality of cases. The use of magnesium was being extended very considerably, and it was being employed in circumstances where perhaps it ought not to be used. Something had to be done to protect it, and the surface sealing method described in the paper was a way of protecting it. It had to be paid for, however, not in money but in trouble. Stoving at 150°C. with Araldite or epoxy resins was no good, and if the stoving was done at that temperature ordinary enamels and some air-drying paints would probably be just as good. To get the last ounce out of the treatment it was necessary to go to a temperature of 200-220°C., although good results might be obtained at a lower temperature.

They had made comparative tests and he had mentioned one specific resin by name, because they had not found anything else which was as good, though there were a number of epoxy resins of the same general type which were very nearly as good. Araldite 985E, however, was better than any of them. They could do with something still better, but that was the best so far available.

Mr. Watts raised the question of what happened to a scratch area and whether or not there was a concentration of effect there. That might or might not be the case. If it was unconnected with other metals and there was no galvanic action possible it would not be the case. There was no undercutting; the corrosion occurred at the scratch and to a very small extent sideways, but that effect was much less than with other types of resin. They ascribed that to the good adhesion. Nine-tenths of the effect was connected with the excellent adhesion between the Araldite as stoved and the metal surface.

Mr. Brace had referred to fluoride anodizing. The bath contained 10 per cent ammonium bifluoride and was operated at normal temperatures and at a fairly high voltage, 100 to 120. The comparison with chromating was not a fair one. Fluoride anodizing was intended to clean the metal from cathodic particles which got into it from shot-blasting operations and so on. It was a cleaning process; nothing was claimed for the protective film which was developed, but the resistance to corrosion of the metal was very greatly enhanced simply because it had been cleaned. Chromating should follow fluoride anodizing if it was desired to get the best out of it. For D.T.D. requirements at the moment it had to follow it, fluoride anodizing being used for cleaning the metal and chromating for passivating it. If a chromate-bearing primer was not used, it was better to paint on a chromated metal.

He had deliberately avoided dealing with the question of zinc chromate, because he regarded that as a second order requirement. So long as a leachable chromate was used the metal would be passivated. The durability of the paint would

be of practical importance, and a chromate may be required with a certain solubility to last longer than another, but from the point of view of passivating the metal it did not matter very much.

Abstract No. 15:

Electroformed Spray Masks.

*By P. Spiro, B.Sc.(Eng.), A.C.G.I., A.M.I.Mech.E.**

THE largest use of spraying masks, which have to be rigid, have to seal off cleanly and neatly the areas not to be painted, and have to be easily cleaned, is on plastics mouldings, such as "3-dimensional" transparent badges with multi-coloured motifs on the back, dials, toys, etc. The manufacturing process described is by electroforming which is also used by the author's company for the production of hard-nickel electroformed high-pressure moulds.

When making spray masks for plastics mouldings, it is essential to use as masters, mouldings produced from the die which will mould the final articles. If the tool in question is a multi-impression tool, different masks should be used for mouldings moulded by different cavities unless these cavities are, for practical purposes, identical, as would be the case with electroformed cavities and sometimes with hobbed cavities. These different masks would have to be electroformed on mouldings produced in the different cavities. Mouldings to be used as masters should be moulded under conditions of minimum shrinkage, and parts not to be sprayed can often be cut away; the moulding is then cemented onto a Perspex plate, the face surrounding the moulding forming the master for an electroformed flange which facilitates holding the masks, etc. Non-essential parts of the moulding can often be cut away to produce a flat parting line instead of an undulating one.

After the mouldings have been thus mounted it is advisable to coat the master with a cold-setting plastic lacquer in those positions where a particularly snug fit is not required and assuming that it has not been possible to cut these portions out altogether and possibly replace them with a Perspex block larger than the moulding.

In the case of die castings and metal stamping the actual articles are used as masters.

Non-metallic masters are silvered chemically after which they are plated (0.01-0.15 in.) in an acid copper bath. Stopping off is then effected with special lacquer and further plating carried out to a total thickness of 0.04 in. in a cyanide bath using a modified periodic reverse plating process. The mask is then sawn open where required, the master removed, and the mask is then trimmed.

*London and Scandinavian Metallurgical Co. Ltd.

The most important problem is the cutting out of those positions which correspond to the areas of the final article which have to be sprayed or painted, and this operation is preferably carried out by the final user of the mask.

Discussion

Dr. N. GROSS (Wilmot-Breeden Ltd., Birmingham) said that he would not recommend the use of more than one colour spraying operation with one mask, due to the resulting complexity of the mask and the risk of bleeding of colours.

Plastic mouldings were often annealed before spraying. During this process a further shrinkage took place, and electroforms must be made using annealed mouldings.

The P.R. cyanide-copper solution was usually operated at about 160°F., and he would have thought that that was likely to distort plastic mouldings. What was the risk of poor adhesion resulting from plating on acid copper with cyanide copper?

Would it not be better to spray steel masters with a thin lacquer coating before silvering, if a mechanical separation of electroform and master was to be made? His company achieved the separation by dissolution of metallic masters with a suitable acid. This method was less likely to result in damage to the electroforms. A raw die casting was always selected for preparing the electroforms.

On the basis of his own experience, he would disagree with the author on the subject of stencils *versus* plug masks. Stencil masks were used only where either the limits of tolerance and the areas to be painted were large or when the use of plug masks was impossible. The best results were usually obtained from plug masks and air jigs to hold them in position.

Mr. P. SPIRO, in reply, said that the suggestion of not using more than one colour in one spray mask was a users' point, but from the point of view of the manufacturer of the mask it was equally welcome, because it simplified matters. The most rational procedure was not only to have one mask for one colour but to have the largest possible number of identical masks of that colour to speed up spraying and prevent interruption for cleaning the masks.

The alkaline P.R. copper solution as they used it was used at an appreciably lower temperature than that mentioned by Dr. Gross. With regard to the adhesion between acid copper and alkaline copper, if the usual precautions were taken the adhesion was as nearly perfect as anything could be in the plating industry.

He had mentioned the use of lacquer or other

(*Continued in page 208*)

MEASURING PLATING DUCTILITY

New Technique and Service Available

THE ductility of a bright nickel deposit is a very important property which can vary with the chemical content of the plating bath in a way which cannot be simply related to the concentration of purity of any particular constituent. Thus, for example, traces of grease dissolved in the bath may considerably affect the ductility of the resulting deposit, and it is therefore clearly of great importance to be able to provide some form of quantitative test by which a check can be kept on the ductility of the plating so that the bath may be kept at its optimum condition.

The degree to which a plated surface can be bent or worked subsequent to plating without developing fine cracks which are likely to be the seat of subsequent corrosion is a measure of the ductility of the deposit. A technique recently developed by Electro-Chemical Engineering Co. Ltd. of Weybridge, Surrey, now permits quantitative determinations of ductility to be made. Test-pieces are used. Each of these consists of annealed brass, and there are two circular holes by means of which they can be attached to the plating rack. The test-pieces are prepared and polished in a standard way because if there are any scratches on the base metal it would create a tendency for the deposited metal to sheer under tension. The plating rack is designed to fit into a 1,500-ml. tall form beaker and carries two test-pieces so that duplicate extension measurements may be made. It is coated with polythene except for the contact points.

Following degreasing, the test-pieces are placed on the rack and passed through a plating sequence in the bright nickel solution to be tested. Test-pieces plated in customers' solutions can be sent to the Electro-Chemical Engineering Co.'s laboratory where they are subjected to a Tensometer test which quantitatively compares the ductility of the specimens with that obtained on similar specimens prepared in standard solutions. Alternatively, samples of the solution in question can be sent and test-pieces will be plated in the laboratory and tested. From these results deductions can be made as to the chemical constitution of the plating baths in which the test operations took place and any deficiencies indicated in these can be made good.

The quantitative control of the ductility of bright nickel deposits which results is an important step forward which should be of great interest to the metal-finishing industry.

SOCIETY OF CHEMICAL INDUSTRY CELEBRATES 75th ANNIVERSARY

SCROLLS containing congratulatory addresses to the Society of Chemical Industry on its 75th Anniversary will be presented at a ceremony in London on July 10, to the president of the Society, Mr. Julian M. Leonard at the Royal Institution.

Nearly 1,000 members and guests from this country and from overseas will be attending the 75th Annual Meeting of the Society from July 9 to 14, at the Royal College of Science. A series of lectures under the title "Achievements of Chemical Industry" will be introduced on July 11, by Dr. L. A. Jordan, C.B.E., F.R.I.C., director of the D.S.I.R. Paint Research Station, who will speak on "Modern Methods of Research."

The Meeting also includes several visits to works and research organizations, and the Society's annual dinner which is to be held on July 11, at the Dorchester Hotel, London.

Institute of Metal Finishing Conference

(*Continued from page 207*)

means slightly to increase the size of the master in all those parts where a very close fit by the mask was not required. So far as extracting it afterwards was concerned, there was no trouble there because it was the mask which had to be preserved and not the master. It was only necessary to raise it to the temperature at which the plastic became rubbery and then pull it out. The problem was different on die castings.

He was interested in Dr. Gross's final point, on the plug mask *versus* the stencil type. There one had the difference between the points of view of the user and the producer. If one were making a spray mask for other people to use, people who at the outset might not have a very clear conception of how they were going to use their masks, depending on actual practise to finalise their ideas, then from the point of view of the producer and plater the stencil type was easier, because the product was plated except where it had to be painted. If the maker of the mask was also the final user and had complete control he might well prefer the plug mask, which also lent itself to further mechanization such as the use of compressed air. The plug type was from an engineering point of view a higher form of mask, but it might call for more cost on the engineering side. On the other hand, if one wanted the shortest cut to some sort of spray mask, with the minimum of costly engineering work, there was much to be said for the stencil type.

FINISHING

NEWS REVIEW

PRODUCTIVITY in the PLATING INDUSTRY

Electroplaters discuss B.N.F.M.R.A. Report

IN Birmingham on June 7 and again in London on June 14 Conferences were staged under the aegis of the British Non-Ferrous Metals Research Association, to which a large number of invitations were extended to representatives of the electroplating industry, to discuss the B.N.F.M.R.A. Report "Productivity in Electroplating." This report which was made possible through financial assistance received under the conditional aid scheme for the use of Counterpart Funds derived from the United States Economic Aid administered at the present time by the International Co-operation Administration, was compiled by two members of the staff of the Association, Mr. G. A. Edwards and Mr. E. A. Ollard, after a survey of twenty-nine electroplating shops, of which the majority were contract platers, although a small number were departments of manufacturing organizations.

In order that the findings of the survey should be as widely applicable in the plating industry as possible it is concerned almost entirely with manually operated plants since the operation of fully automatic plants could only properly be dealt with in relation to specialized output requirements. The purpose of the survey has been to direct attention to instances where production practice can be improved, and while no attempt is made to present a picture of the general state of the plating industry in this country, an effort has been made to draw attention to the possibilities of effecting improvements even in plants which appear to be running reasonably efficiently.

Layout of Plant

An important cause of reduced efficiency which was revealed in the course of the survey is the layout of the plant. In many cases buildings of unsuitable size and shape were bound to be in use and the location of the various units of equipment had arisen more as a result of periodical additions sited according to the dictates of space availability, rather than with due consideration for the work flow.

The question of efficient utilization of plant and labour has also been closely studied by the investigators who found that in a number of the works visited, both plant and labour, were not always kept fully employed. This was particularly noteworthy as during the period of the survey most firms were more than adequately provided with work and the reasons for idle plant largely arose from inadequate production planning. For example, hold-ups were noted arising from labour bottle-necks in such preliminary departments as polishing or jigging.

Among other wasteful practices noted were the use of odd-size vats which meant that in transferring work, either part of the vat capacity is not utilized, or the work has to be re-racked between operations. Scouring with pumice powder is still regarded by many platers as essential to ensure good adhesion, although in most instances equally good results can be obtained by the use of a properly designed cleaning cycle. Some cleaning cycles observed in use also appeared to be unnecessarily complicated and could have been reduced without detriment to the final coating. The re-racking of components between the bright nickel vat and the chromium vat occurred frequently enough to merit comment and was necessitated by such causes as unsuitability of jigs, differences in vat sizes, wiring marks on bright nickel requiring mopping out, and insufficient brightness of nickel coating arising from poor control of solution.

The report contains a number of other very pertinent comments and observations on current plating practice which are well worthy of detailed study. The final conclusions and recommendations are summed up as follows:

There is considerable scope for increasing output from existing plant and from existing labour. Most managements are fully aware of this and anxious to improve the position but are handicapped by the lack of trained men at all levels, but more especially at the foreman level. A scheme for training such men is urgently needed.

The lay-out should be designed from the point of view of convenience of production and not, as is often the case, from the point of view of ease of installation.

The standard of work aimed at is high, but sufficient care is not always taken to ensure that work is uniformly good. This applies particularly to control of deposition conditions, such as filtration, temperature of solutions, cleanliness of cathode rods and suspender hooks and time of deposition. Chemical control is usually adequate.

Automatic and Semi-automatic Plant

In the majority of shops visited there was no case for fully automatic plating machines, but in many cases careful consideration should be given to the installation of semi-automatic plant. More consistent quality and quantity of output is thus obtained, quite apart from consideration of the better utilization of man-power.

Plant utilization should be improved by:—

(*a*) Using jigs wherever possible and, where these are not justified, using frames. Only when the work is of large dimensions should it be wired directly to the cathode rod.

(*b*) Studying the method of vat loading, the aim being to keep the vats full for as much of the working day as possible and the operator working at a steady, even pace. Work-study techniques would be useful tools for determining the best methods.

(*c*) Standardizing the size of vats so that the same jigs or frames can be used throughout the process.

The best utilization of plating-shop labour should be ensured by efficient Production Planning and Progress, by good plant lay-out and by eliminating unnecessary operations.

(*Continued in page 210*)

Productivity in the Plating Industry

(*Continued from page 209*)

Thought should be given to reducing skilled polishing labour by:—

(*a*) Using nickel solutions of the "levelling" type.
(*b*) Using barrel polishing methods where possible.
(*c*) Using special jigs to hold work against the polishing wheel.

Where much barrel plating is undertaken, consideration should be given to the newer types of barrels and to mechanical handling.

More attention should be paid to maintenance, particularly the cleaning of cathode rods, connexions, etc., gas burners, pumps and filters. The shop generally should be kept clean and well painted.

There is room for economy in the use of heat, electricity and water.

Incentive Schemes

It is realized that it is difficult to operate incentive schemes, particularly in job plating shops. Several such schemes, however, have been seen in operation and, although there are definite drawbacks, the conclusion has been formed that, where these schemes are applicable and well devised, they can be beneficial. Each case, however, must be considered on its own merits.

There is an urgent need for a uniform system of costing to enable managements to assess the profit or loss of individual departments and of the items being processed. It would also help to reduce the wide range of quotations now tendered. This matter of costing was considered to be of sufficient importance to merit a separate investigation, which has been undertaken by staff of the D.S.I.R.

The greatest difficulty in increasing productivity is probably the fluctuations in the loads and the variations in the character of the work. To some extent this might be mitigated by the platers themselves adopting a certain amount of specialization in the articles they process. While this is comparatively easy when a firm is a member of a group, it has also been worked to some extent by private arrangements between several plating firms—one firm, for example, concentrating on anodizing, another on barrelling, another on zinc plating, and so on.

COLOUR IN THE KITCHEN

A Survey of Current Consumer Trends

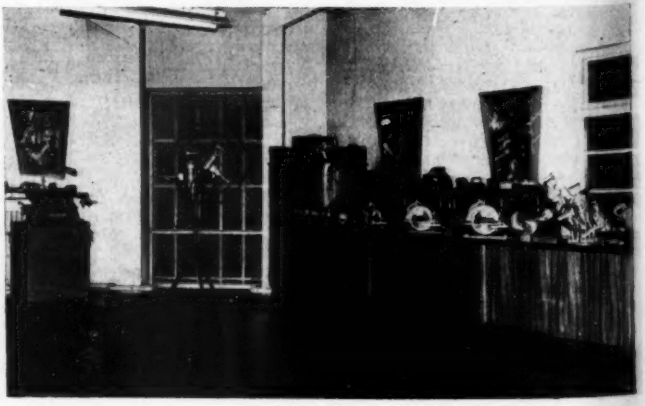
BEFORE introducing their new line of Prestcold refrigerators incorporating a coloured top and base, the Pressed Steel Co. Ltd., conducted an intensive survey of the views of British housewives and representatives of a number of professions. A questionnaire comprising eight simple questions relating to the use and combination of colour in the kitchen was sent out and the replies were carefully analyzed. In addition to housewives the views were sought of doctors, oculists, psychiatrists, interior designers, architects, teachers, and editors of women's magazines.

Where positive replies were obtained to the questions they revealed an unequivocal preference for bright colours to be used in connexion with kitchen equipment. On the question of choice of actual colour combinations from the range presented, there was less unanimity, particularly among housewives, although a preference for a red top and a black base with either a white or cream bodied refrigerator was expressed by over 40 per cent of this class. In general combinations of red, white and black, red, cream and black, and blue, white and black gained the greatest amount of support, among all classes with the exception of the interior designers, most of whom opted for less usual combinations. In this they received a measure of support from representatives of the teaching profession and of women's magazines.

The new Prestcold dual-colour model refrigerator

While it may appear from this that popular consumer taste still lags behind the current trend as typified by those concerned with guiding it, there is nevertheless a clearly defined preference for the introduction of real colour into the modern kitchen.

On April 26 the new Black and Decker Ltd. branch office at Knott Mill, Manchester, was officially opened. Representatives of the company based at this office cover the area of Lancashire, Cheshire and North Wales. The new building houses special facilities for users of the company's tools. There is a demonstration theatre (shown below) which is equipped for practical demonstrations of all types of industrial portable-electric tools, for showing films, and for lectures at which up to 70 people can be accommodated. The equipment of the service station includes fitting benches, a Laycock "Air-Speed" cleaning tank, high-voltage earth-testing equipment, running-testing gear, and a paint-spray booth, served by a "BEN" compressor, for restoring damaged finish. The entire building is centrally heated by water from an ideal "Standard" No. 2 gas boiler. The address is Black and Decker Ltd., Knott Mill, Manchester; telephone number is BLAckfriars 8865.



THE TITANIUM PIGMENT STORY

Colour Film of Production and Uses of TiO_2

IT is now more than 150 years since the Reverend William Gregor, a Cornish parson, painter, musician, and amateur chemist discovered titanium oxide while examining the composition of the black sand to be found on the beach at Manaccan. For 100 years no commercial use was found for this material, but shortly after the first World war a commercial method of extracting the white titanium oxide from its ore ilmenite was developed. This oxide quickly established itself in the pigment-using industries because of its greatly superior covering power over that of all other white pigments known at that time.

The story of how titanium oxide is obtained in its rutile form from the ore and of the research and development behind its application in a wide range of industries is told in a 23-minute film produced in full colour by British Titan Products Co. Ltd., Coppergate, York.

The film shows how the first titanium oxide produced some 30 years ago was in the form of anatase, which although exhibiting desirable pigment properties, suffered from the disadvantage of chalking when used in paints for exterior service. A method however, was soon developed for converting the oxide into another of its distinct crystalline forms, rutile which did not manifest this undesirable property.

British Titan Products Co. Ltd., is the largest producer of titanium oxide outside the United States, and is the third largest producer in the world. The original factory was started in 1934 at Billingham, Co. Durham. The Grimsby plant, which features very largely in the film, commenced operations in 1949 and has been continuously expanding ever since. When the present programme of construction is completed early next year this plant will produce 55,000 tons of titania a year, and it is planned to increase this figure even more. In addition the company operates a plant in Australia, has an interest in a small Indian plant and is erecting a plant in South Africa, while part of the ore requirements are obtained from the company's own mines in the Gambia, West Africa.

After describing how the white pigment is extracted from the crude ore and processed into rutile, the film shows something of the control of the quality of the product and the evaluation of its performance as a pigment in paint. It also illustrates the use of the oxide in such materials as vitreous enamel, rubber, plastics, linoleum and paper, and gives some idea of the extent to which it is used in a wide range of everyday articles.

The film, which is admirably produced in Eastman colour, is available in 16-mm. prints for showing to professional and trade organizations, and similar bodies, on application to British Titan Products Co. Ltd., York.

Left. Part of the rotary filter installation on which titanium oxide from the digestor is washed free of contaminating salts.

Above. Exposure testing of titania pigmented paints.

Left. Testing the brushability of titania pigmented paint at the Billingham Technical Sales Service Laboratory.

NEW BORAX SET-UP

A REORGANIZATION of Borax Consolidated Ltd. has taken place, as a result of which Borax Consolidated Ltd., on becoming a holding company, has ceased its trading activities, which will in future be carried on by operating subsidiary companies. Borax Consolidated Ltd.'s experienced staff outside the U.S.A. has been transferred to Borax Consolidated (Sales) Ltd., which is the present name of the operating subsidiary in this country. In due course the name of the holding company will be changed to Borax (Holdings) Ltd., and on the same date the operating subsidiary in this country will change its name from Borax Consolidated (Sales) Ltd. to Borax Consolidated Ltd. Borax Consolidated (Sales) Ltd. will trade from Borax Consolidated Ltd.'s present business address and all communications should be addressed until further notice to that company under the name Borax Consolidated (Sales) Ltd.

World Metallurgical Congress

Sponsored by the American Society for Metals, the Second World Metallurgical Congress, will be held in Chicago, U.S.A., from November 2 to 8, 1957.

COMPANY NOTES

Electric Tool Company Expands Birmingham Premises

IN order to deal with ever expanding business in the Midlands, Wolf Electric Tools Ltd. have purchased the property adjacent to its Birmingham Sales and Service Branch at 47, Barker Street, Birmingham 19.

The acquisition of this property will enable the existing showroom to be expanded, and it is planned, in addition to Industrial and Cub portable electric tools, to install a complete range of Wolf transport service equipment for demonstration purposes. This will be of interest to motor manufacturers, service stations and garages.

The branch, the telephone number of which is Northern 3938/9/30, is managed by Mr. P. Frost.

* * *

New Industry Prospers in Trinidad

THE £5 million British Paints Group of Companies factory in Port of Spain, Trinidad is likely to be extended as a result of the quickening pace of industrial development and prosperity in the area.

Mr. W. E. Jeffries, 39 year old general manager of British Paints (Caribbean) Ltd., who has just arrived back in this country said that the possibility of still further expansion of manufacturing capacity is under consideration by Mr. J. W. Adamson, chairman of British Paints Ltd., the parent company.

Apart from the technical staff the majority of the company's employees at the Port of Spain factory are local people. Mr. Jeffries is full of praise for their adaptability. " Ours is a pioneer industry in the island," he said, " yet over the past two years our staff have learned quickly and well and some of them are already well represented at the administrative level."

* * *

Change of Address

Industria Metalchimica Ing. A. and F. Stein, who represent in Italy the Electro Chemical Engineering Co. Ltd., of Weybridge, announce that all the company's commercial and technical offices have now been removed to: Via Fontanili, 34, Milan. The telephone numbers are 390.418 and 390. 839.

S.C.I. CORROSION GROUP

Annual General Meeting

THE fifth annual general meeting of the Corrosion Group of the Society of Chemical Industry was held recently in the rooms of the Chemical Society, Burlington House. The chairman, Mr. T. Henry Turner, presided.

Following the formal adoption of the minutes of the previous annual general meeting, the financial report was presented by the Hon. Treasurer, Mr. W. E. Ballard, and the committee's report on the activities of the past session was presented by the Hon. Secretary, Mr. S. C. Britton. Mr. Britton was pleased to be able to report an increase in the membership of the Group and a satisfactory technical programme during the session. This had comprised four evening meetings, a half-day meeting at Grangemouth, two half-day symposia in Birmingham, and an all-day symposium in London. The London meeting had dealt with " The Protection of Cable Sheathing " and had been well attended, including a number of overseas visitors. The Birmingham meeting had been held on the theme " The Prevention of Corrosion in Packaging and Storage."

The meeting at Grangemouth on " Corrosion Control by Water Treatment " had been very successful, and so also had been the evening meetings in London.

Following the presentation of the report of the committee, the constitution of the committee for the coming session was announced by the Chairman. This involved a number of changes. Dr. J. C. Hudson had retired from the Vice-Chairmanship and had been succeeded by Dr. S. G. Clarke. Dr. P. T. Gilbert had resigned as Hon. Recorder and was to be succeeded by Dr. E. C. Potter, and Dr. W. H. J. Vernon had resigned from the Chairmanship of the Education Panel and was being succeeded by Dr. T. P. Hoar. The three members due to retire from the Committee under the rules of the constitution were Dr. S. G. Clarke, Dr. T. P. Hoar and Dr. F. Wormwell. These vacancies would be filled by the election to the Committee of Dr. J. C. Hudson, Mr. G. H. Jenner and Mr. P. A. Raine. The Committee for the coming session is therefore as follows: Chairman: Mr. T. Henry Turner; Vice-chairman: Dr. S. G. Clarke; Hon. Secretary: Mr. S. C. Britton; Hon. Treasurer: Mr. W. E. Ballard; Hon. Recorder: Dr. E. C. Potter; Ordinary Members: Dr. F. A. Champion, Dr. W. F. Higgins, Dr. J. C. Hudson, Mr. G. H. Jenner, Mr. J. F. Kayser, Mr. L. Kenworthy, Mr. P. A. Raine, Mr. R. Ll. Rees, and Mr. C. E. Richards; Additional Members with a seat on the Committee: Dr. T. P. Hoar, Mr. L. W. Stubbs (Chairman and Secretary respectively of the Education Panel). Mr. H. S. Campbell and Dr. J. Edwards were re-elected Auditors for the coming session.

Following the business meeting the Spring Lecture was delivered by Dr. U. R. Evans, who chose as his subject " Pitting and Cracking."

FLAME CLEANING

THE first of its kind in the country, an elevated water tank which will hold half-a-million gallons has been constructed by the Motherwell Bridge and Engineering Co. Ltd., for Vauxhall Motors' new Bedford truck plant at Dunstable.

During construction, the tank was flame-cleaned both internally and externally with British Oxygen's C.H. and F.H. type descaling equipment using both 4-in. and 6-in. nozzles. This process removes rust and reduces the likelihood of corrosion. The whole operation required approximately 90 cylinders of both oxygen and dissolved acetylene, and a total of 162,000 cubic feet of oxygen and 18,000 cubic feet of dissolved acetylene were used. Four men were employed on the flame cleaning, which took two weeks to complete.

BARRELLING DEMONSTRATION

In order to introduce their process of precision barrel finishing to the cutlery and allied industries, a reception was staged recently in Sheffield by Rotofinish Ltd., Hemel Hempstead, Herts. This was attended by a number of representatives of local industries who showed great interest in the demonstration of techniques and equipment employed in operating the range of processes offered by the Company.

The degree of control which can be exercised over the process and the quality of the final finish obtained, which is variable over wide limits, represent a considerable advance on earlier less exact tumbling techniques.

Instances were cited of savings in cost of up to 80 per cent on the deburring of certain components and the process has found wide application in industries where the finishing of complex components to fine limits is a necessary operation.

TECHNICAL BOOKSHELF

"*The Surface Treatment and Finishing of Aluminium and Its Alloys*," by *S. Wernick, Ph.D., M.Sc., F.R.I.C., F.I.M. and R. Pinner, B.Sc. Published by Robert Draper Ltd., 85, Udney Park Road, Teddington, Middx. 580 pp. Price 84s. net.*

IN the preface to this book, the authors explain that they have endeavoured to present a description of all the processes that are available for the surface finishing of aluminium and its alloys.

In this they have succeeded within the limitations imposed by the number of pages of text.

The main subject matter is preceded by about 50 pages dealing with the available aluminium alloys and the corrosion of aluminium.

Following this are sections on mechanical surface treatment, electrolytic and chemical polishing processes, chemical and anodic oxidation, and the usual after-treatment processes such as dyeing and sealing.

The processes for electroplating of aluminium are discussed in great detail, and there are short sections on organic finishing, vitreous enamelling and metal spraying.

The book is, in the strictest sense of the word, a reference book, in which a large number of processes are mentioned uncritically, and with little direction of choice or recommendation to the reader.

It is therefore, mainly of use to managers and technicians requiring a starting off point for further detailed investigation.

The authors are to be congratulated on the up to the minute references that are included in the excellent bibliography.

As many of the opinions and conclusions are those of the original authors of the patents and technical literature, they are sometimes contradictory, and to persons having little knowledge of the subject, some confusion might arise.

There are a number of printing errors which however, are mostly self-evident, and will doubtless be rectified in future editions.

This is the first book in the English language containing an up-to-date collection of references on surface treatment of aluminium, and will be of great use to all those interested in this field of metal finishing.

V. F. Henley.

"*Die Praxis der anodischen Oxydation des Aluminiums*," by *W. G. Hübner and A. Schiltneck. Published by Aluminium-Verlag, G.M.B.H., Düsseldorf. 355 pp. Price DM 19.60.*

THE Germans take anodizing somewhat more seriously than the British, chiefly because of the much wider use of aluminium for architectural work, much of which is for outdoor use. The book entirely fulfils its title by devoting the bulk of its space to the practical carrying out of anodizing. Thus only the first third deals with solution compositions and operating conditions, but clear instructions for preparation, operation and analysis of degreasing, etching, chemical or electrolytic brightening solutions are given, as well as for sulphuric, oxalic or chromic acid anodizing processes, chemical oxidation treatments, dyeing and sealing procedures. The minimum of theory is included. Almost another third of the book is then devoted to a very detailed consideration of plant for carrying out these processes, from the building and its services down to those details which are often the key to success. This part includes no less than 40 pages devoted to jig design and manufacture alone, and 25 pages to tank construction. 68 pages are devoted to the rather special methods of grinding and polishing aluminium. The whole text of the book, supported by 255 well-chosen line diagrams or half-tone illustrations, testifies to the wealth of practical experience drawn upon, which covers treatment of articles ranging from watch parts to extrusions 30 ft. long and panels 20 ft by 4 ft.

Advice on the specific dyes to be used in colouring, with special respect to their light and weather resistance, seems to be rather lacking, and the section on testing and inspection of anodic films is also quite inadequate. However, the book can be strongly recommended and it may be added that it is written in comparatively easy German.

G. E. Gardam.

Change of Telephone Number

With effect from July 7, the telephone number of **Aero Research Ltd.**, Duxford, Cambridge, will be Sawston 2121. The Telex number is 10-101.

WATER POLLUTION RESEARCH

IN their Annual Report for 1955 the Water Pollution Research Board review the first complete year's work which has been carried out in the new Water Pollution Research Laboratory at Stevenage. With the facilities now available it has been possible for the organization to collaborate much more closely than formerly with other bodies interested in the prevention of pollution.

The report of the director of research, which accompanies that of the Board, summarizes briefly the results of the chief investigations made during the year, of which the following are examples in the field of this Journal.

Synthetic Detergents

Work on synthetic detergents has shown that their toxicity to fish is due chiefly to the anionic surface-active agent which they contain. It appears that when sewage containing detergent is treated by biological filtration the effluent, which will contain a certain concentration of detergent as determined by the ordinary method of analysis, is less toxic than water to which the same concentration of detergent has been added. The reason for this is not known and experiments are being continued with larger quantities of effluent from pilot-scale activated sludge plants. The resistance of fish to low concentrations of dissolved oxygen is reduced if small quantities of detergent are added to the water.

Industrial Waste Waters

Work carried out during the year included studies with pilot plant on the biological destruction of cyanide, and the treatment of waste oil-in-water emulsions.

For the cyanide experiments a filter 15 ft. deep and 1 ft. wide was constructed with sampling off-takes, the filter itself being made entirely of non-metallic materials and filled with gravel. Sodium-cyanide solution (15 p.p.m. HCN) was passed through the filter for 7 days. Although the filter had not been inoculated, 66 per cent of the applied cyanide was lost. On the 7th day an inoculum of coke was added and complete removal of the cyanide was obtained after 16 days. The HCN concentration had to be increased to 57 p.p.m. before measureable concentrations of cyanide could be detected at depths of more than 6.5 ft. from the top of the medium.

TECHNICAL AND INDUSTRIAL APPOINTMENTS

It has been announced by **R. Cruickshank Ltd.**, Birmingham, chemical manufacturers and electroplating engineers, that Mr. A. J. L. Nash, B.Sc., A.C.G.I., M.I.E.E., formerly

Mr. A. J. L. Nash

general manager, has been appointed managing director of the company. A programme of extensive developments within the field of its specialized products and services has been launched by the company.

* * *

The Minister of Education has appointed Mr. T. C. S. Morrison-Scott as director of the **Science Museum,** Kensington, in succession to the late Dr. F. Sherwood Taylor.

* * *

The Group labour manager of **British Chrome and Chemicals Ltd.,** 6, Arlington Street, London, S.W.1., Mr. L. W. Grainge, has been appointed to the board of that company and also to the board of British Chrome and Chemicals (Holdings) Ltd., as a special director.

* * *

Following the appointment of Dr. T. Kennedy, M.Sc., as personal assistant to the chemical sales director of **Joseph Crosfield and Sons Ltd.,** Warrington, Lancs., the post of manager of the technical service department has been taken by Mr. J. G. Walker, F.R.I.C., A.M.I.Chem.E.

TRADE and TECHNICAL PUBLICATIONS

Non-rinsing Iron Phosphate Process: A leaflet issued by The Walterisation Co. Ltd., Waddon Marsh Way, Purley Way, Croydon, Surrey, describes the Walterisation C.1 process which produces a massive microcrystalline coating of pure ferrous phosphate.

The simplicity of the process makes it suitable for manual operation and the plant may consist of as little as a trichlorethylene degreaser, a phosphating tank and suitable means of drying. The phosphating tank may be constructed of best quality mild-steel plate, ¼ in. thick, and all the joints should be double welded. As the solution reacts with the tank it is more economical in the long run to construct the container of stainless steel or other suitable acid-resisting material.

The Brook: In the current issue of this quarterly magazine published by Brook Motors Ltd., Huddersfield, is an interesting article dealing with the manufacture of paint at the works of Jenson and Nicholson Ltd., London, and the part that Brook motors play in the production.

It deals with the production of synthetic resin paints, varnishes, shellacs, slow lacquers, car finishes, emulsion paints and enamels.

The Bonderizer: In the May, 1956, issue of this journal published by The Pyrene Co. Ltd., Metal Finishing Division, Great West Road, Brentford, Middlesex, there is an article dealing with the production of gears and cams at the E.N.V. Engineering Co. Ltd., and the use that is made of the Parco-Lubrite phosphate-coating system. The oil absorptive property of this coating assists lubrication especially during the running-in period and also reduces the risk of scuffing, galling, pick-up or local welding as a result of high-pressure rupture of the oil film.

Another interesting article deals with a new Bonderizing technique developed to facilitate forming titanium and its alloys and also to reduce friction on moving parts fabricated from these materials. This process was introduced at the Exhibition held recently in conjunction with the Spring Conference of the Sheet and Strip Metal Users' Technical Association.

The sequence of operations for this new process, all of which are carried out at room temperature, is that the cleaned work is flash pickled and afterwards water rinsed in two stages. It is then Bonderized, water rinsed again, and dried prior to the application of the drawing lubricant. The gas pick-up is negligible and there is no risk of hydrogen embrittlement, which from the nature of the process might have been thought possible.

Hard Anodizing: A booklet published by Hard Aluminium Surfaces Ltd., 38 Mair Street, Glasgow, S.W.1., describes the Hardas process which is claimed as the first in the world to produce a satisfactory hard anodic coating on aluminium on a commercial scale.

Information is given on the uses of hard anodizing and it states that the coating produces a dimensional increase equal to one half of its thickness. This coating causes a roughening of the surface to the extent of 10 micro-in. per 0.001 in., which may be ground, honed or lapped to a very smooth finish. The removal of 0.0005 in. is sufficient to provide a good finish on homogeneous metal.

All wrought aluminium alloys can be hard anodized and most of the casting alloys. Hard anodizing causes a reduction in the fatigue strength of aluminium of about 25 to 30 per cent for the strong alloys.

It is also claimed that the hardest hard anodic coating is considerably harder than hard chrome plating. Parts of an article can be hard anodized and other parts can be left untreated or given an ordinary anodic coating.

Fritted-in Colour: The technical aspects of obtaining coloured vitreous-enamelled coatings by the use of frits into which colouring compounds have been incorporated during the melt was discussed in the November, 1955, issue of this Journal. This article has now been reprinted as a technical note by British Titan Products Co. Ltd., Coppergate, York. One of the conclusions drawn from the investigations carried out is that the colour stability of enamels obtained by smelting the oxides of certain metals into a titanium self-opacified enamel frit, is superior to that of orthodox enamels to which colouring oxides are added at the mill.

The presentation of the technical information is considerably enhanced by the provision of coloured panels reproducing exactly the shades obtained by the various oxide additions.

Abrasive Belting: A circular from Norton Grinding Wheel Co. Ltd., Coated Abrasives Division, Welwyn Garden City, Herts, introducing the new Series 48 Metalite abrasive cloth is remarkable in that it is printed on a sample of the material itself, thus enabling potential customers to assess the properties of the product for themselves.

This new Behr-Manning abrasive belting is coated with aluminium oxide with a special adhesive on a strong cloth backing.

Latest Developments in PLANT, PROCESSES and EQUIPMENT

Plating Thickness Meter

IN the April, 1955, issue of this Journal a detailed account was published of the principle of operation of an instrument for measuring the thickness of electrodeposited coatings, developed by the British Non-Ferrous Metals Research Association. This instrument, which provides a simple, robust, non-destructive means of measuring the thickness of plated and other metallic coatings irrespective of whether the coating and basis metal are magnetic, has now been made commercially available by Nash and Thompson Ltd., Oakcroft Road, Chessington, Surrey. (Fig. 1).

Briefly, the principle of operation of the instrument is that a hot probe is applied to the surface of the specimen and gives rise to a temperature gradient through the coating into the basis metal. Consequently a thermoelectric e.m.f. is generated at the inter-metallic interface immediately beneath the probe tip. This e.m.f. is measured between the hot probe and a cold probe connected to the specimen at a more remote point.

The instrument is in three parts, the hot probe, the "cold probe," and a case housing the amplifier, meter, controls and power supplies.

The hot-probe unit consists of the probe itself, incorporating a heating element, spring mounted in an outer shell. Little more than the tip of the probe, of 0.062 in. spherical radius is exposed. The spring serves to operate electrical contacts to indicate when the correct probe pressure is being applied.

The "cold probe" is available in a number of interchangeable forms, the most common of which are:—

Fig. 1.—Plating thickness meter.

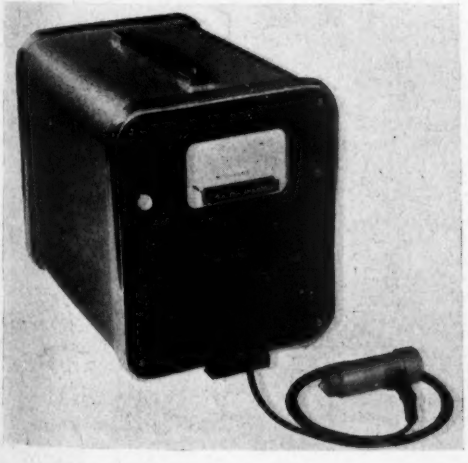


Fig. 2.—Light-weight spray gun.

Pencil type, most useful on intermediate-size flat specimens with a hand-held hot probe. Clip type, for exploring large self-supporting surfaces with a hand-held hot probe. Base-plate type for repetitive testing with jig-held hot probe. Clamp type for testing on small specimens especially those which are not flat.

The meter unit is a contact modulated d.c. amplifier indicating on a meter with a 4 in. scale. Controls are provided for sensitivity and zero setting. In the same case are incorporated the heater supply for the probe and the load-pressure indicator lamp and supply. Both the probe heater current and the amplifier sensitivity are stabilized. At present the meter indicates in arbitrary units and may be calibrated against standard specimens measured by other methods. It is intended eventually to fit demountable scales calibrated directly in coating thickness for the more common combination of plating and basis metals.

Light-weight Spray Gun

THE development of a new spray gun of original design (Fig. 2) has been announced by Alfred Bullows and Sons Ltd., Long Street, Walsall, Staffs.

The main features of the gun are that it gives good handling and balance, is extremely light in weight, and reduces operator fatigue.

The trigger design is a noteworthy feature. The operator's index finger lies naturally along the full length of the trigger, giving precise and accurate

control by very light pressure. The spray width can be quickly and accurately adjusted by a knurled control screw on the side of the gun, and a wide range of nozzles is available for most applications.

The gun can be pressure fed from a pressure container or gravity bucket and will operate with a syphon cup.

It is primarily intended for matching and shading work where a high rate of paint flow is unnecessary, and where sensitivity and delicacy of control is necessary for fine shading and stencilling.

The body is a Duralumin forging with all wearing threads in brass inserts, and the needle is adjustable for wear.

Mist-free Sprayers

FULL details of a new mist-free paint sprayer, which was on show for the first time at the Factory Equipment Exhibition, have just been released by Miracle Sprayers (Distributors) Ltd., 64A King's Road, London, S.W.3, the sole concessionaires in this country of these Sicmo-Bendix guns (*see* Fig. 3).

The guns are designed in such a way that the projected paint is enveloped by a muff of air, which guides and protects the atomized paint, and so, it is claimed, practically eliminates mist. The use of a greater volume of air at a lower pressure decreases velocity and eliminates bounce. This, it is claimed, results in a saving of paint of at least 30 per cent., also the filtered oil-free air produces superfine finish and eliminates " bloom " even in humid weather.

The guns can be used with special Sicmo-Bendix portable air-compressor equipment or with a high-pressure factory air supply. The latter ones have been modified by the inclusion of an air transformer in the handle, which operates on the principle of an injector. The high-pressure jet entrains additional air, thus increasing the volume while reducing the pressure.

The turbo-compressor is designed for continuous running without overheating. The armature shaft and impellers runs in 3 grease-packed ball bearings, and the compressor requires no lubrication. Filtered oil-free air is delivered at 12 deg. warmer than the ambient air and is therefore dry under all conditions of humidity.

Bright Cadmium Plating

A NEW bright cadmium plating process (No. 53) based on a development recently tested in the United States by Efco-Udylite is now available in this country from the Electro-Chemical Engineering Co. Ltd., of Woking, Surrey. Advantages claimed for this process include a wider bright plating range, higher current density of operation, freedom from pitting, minimum sludging and simplicity of control.

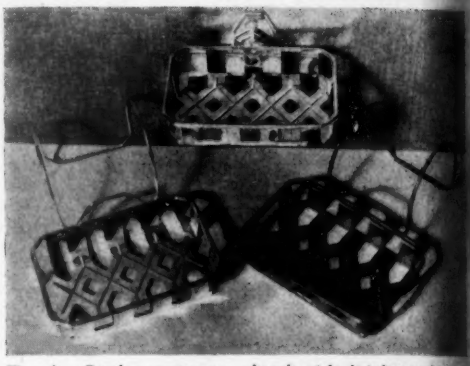


Fig. 4.—Steel components plated with bright cadmium.

The type of article to be plated governs to a large extent the composition of the solution used. Thus, process No. 53A is for general use including work plated in manually operated tanks, semi-automatic or fully automatic machines; process No. 53B is used for deeply recessed articles where complete coverage with cadmium is important; and process No. 53C is used for barrel plating.

The bath constituents consist of cadmium of a content which varies with the items to be plated, sodium cyanide which provides solution conductivity and anode corrosion, caustic soda which is formed when cadmium oxide and sodium cyanide are dissolved in water, sodium carbonate which is unavoidably formed by decomposition of the sodium cyanide, and a proprietary liquid brightener which is added to the plating solution in quantities depending on the cadmium content of the bath and the brightness required.

The operating temperature is 75 to 95°F. Higher temperatures permit higher current densities but are harmful to the brightness and throwing power. Lower temperatures decrease the conductivity, therefore lowering the current density considerably. As with any other plating process adequate cleaning, pickling and rinsing facilities are necessary to ensure that the deposit possesses a satisfactory degree of adhesion. Cadmium plate should not, of course, be put on articles to be used in contact with foodstuffs.

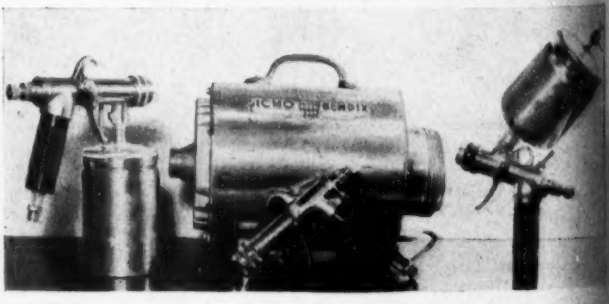


Fig. 3.—Three models of mist-free paint spray guns and portable compressor.